# EXPANDED ENGINEERING EVALUATION/ COST ANALYSIS FOR THE BUCKEYE MINE SITE

**Madison County, Montana**

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## 1.0 INTRODUCTION

The Buckeye Mine is located near the town of Brandon, Montana, approximately 3 miles east-northeast of the town of Sheridan in Madison County, Montana. This document presents the Expanded Engineering Evaluation and associated Cost Analysis (EE/CA) for the reclamation of the abandoned tailings and waste rock piles included in the Buckeye Mine site. The data used for this evaluation was prepared by Olympus Technical Services, Inc. (Olympus) and submitted to the Montana Department of Environmental Quality Mine Waste Cleanup Bureau (DEQ-MWCB) in the site characterization report for the Buckeye Mine site (DEQ-MWCB/Olympus, 2005).

The project area includes the Buckeye Mine tailings and waste rock and the Brandon Mill waste area. The Buckeye Mine tailings and waste rock are currently ranked No. 19 on the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau (DEQ-MWCB) Priority Sites List. The Brandon Mill area is not ranked on this list.

The site is located within the E½, SE ¼ of Section 19 and the NW¼, SW¼ Section 20, Township 4 South and Range 4 West, Montana Principal Meridian (Figure 1-1). Figure 1-2 is an aerial orthophotograph taken in August 1995 that shows an overview of the site area. The site is located within the Mill Creek drainage, a tributary of the Ruby River. The site is accessible by taking Montana Highway 287 to Sheridan, turning east onto Mill Creek road and proceeding approximately 3 miles to Brandon. The lower portion of the site (TP-4 and WR-5) is located along Mill Creek at Brandon. What is believed to be the former Brandon Mill is located across Mill Creek Road from tailings pile TP-4 (Figure 1-2). The upper portion of the site is located approximately ¼-mile to the northeast in an unnamed, ephemeral tributary to Mill Creek. The upper portion of the site is accessed via a gravel road at the west edge of Brandon.

The Buckeye Mine is located mostly on patented mining claims within public lands managed by the U.S. Bureau of Land Management (BLM). A minor portion of the site is on public lands managed by the BLM. The site is comprised of five tailings ponds, five waste rock piles, a small building, an ore chute/loadout structure and the former Brandon Mill area. Three of the tailings piles and four of the waste rock piles are located near an unnamed ephemeral drainage. The fourth tailings pile and fifth waste rock pile are located on the south and north banks, respectively, of the perennial stream Mill Creek. The Brandon Mill and a small tailings pile TP-5 are located on the south side of Mill Creek, across Mill Creek Road from the remainder of the site.

Field Sampling, Laboratory Analytical and Quality Assurance Project Plans were prepared for the site in March 2004 (DEQ-MWCB/Olympus, 2004a, 2004c and 2004d). These documents outline the sampling and analytical methods used to generate the site characterization database. The site characterization work was performed during July 2004. The Site Characterization Report (DEQ-MWCB/Olympus, 2004) presents the data with the following evaluations:

- Background Soil Quality;
- Mine/Mill Waste Characteristics;
- Sediment Characterization;
- Surface Water and Groundwater Characteristics;
- Assessment of Airborne Particulate Emissions;
- Assessment of Physical Hazards;

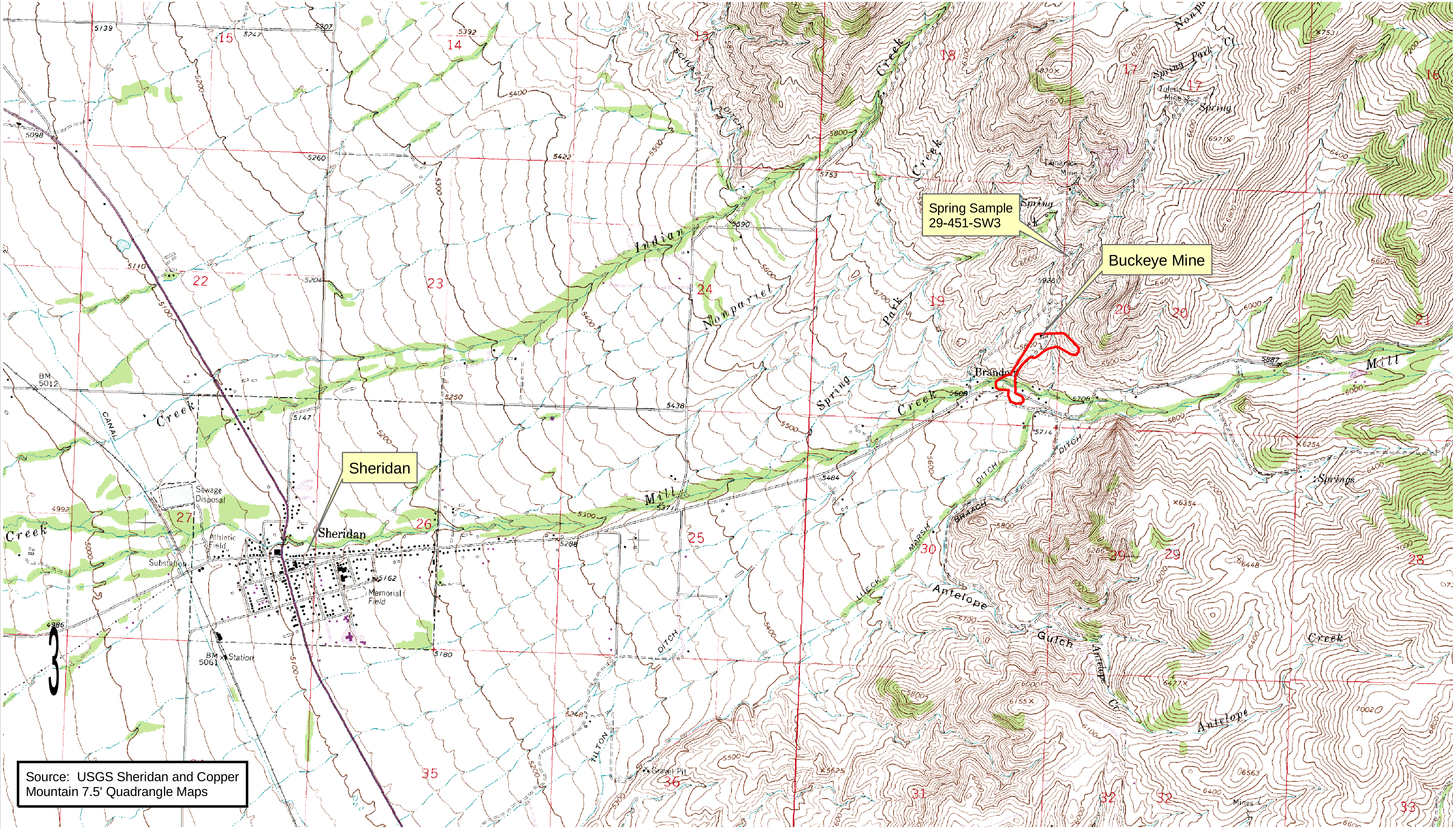


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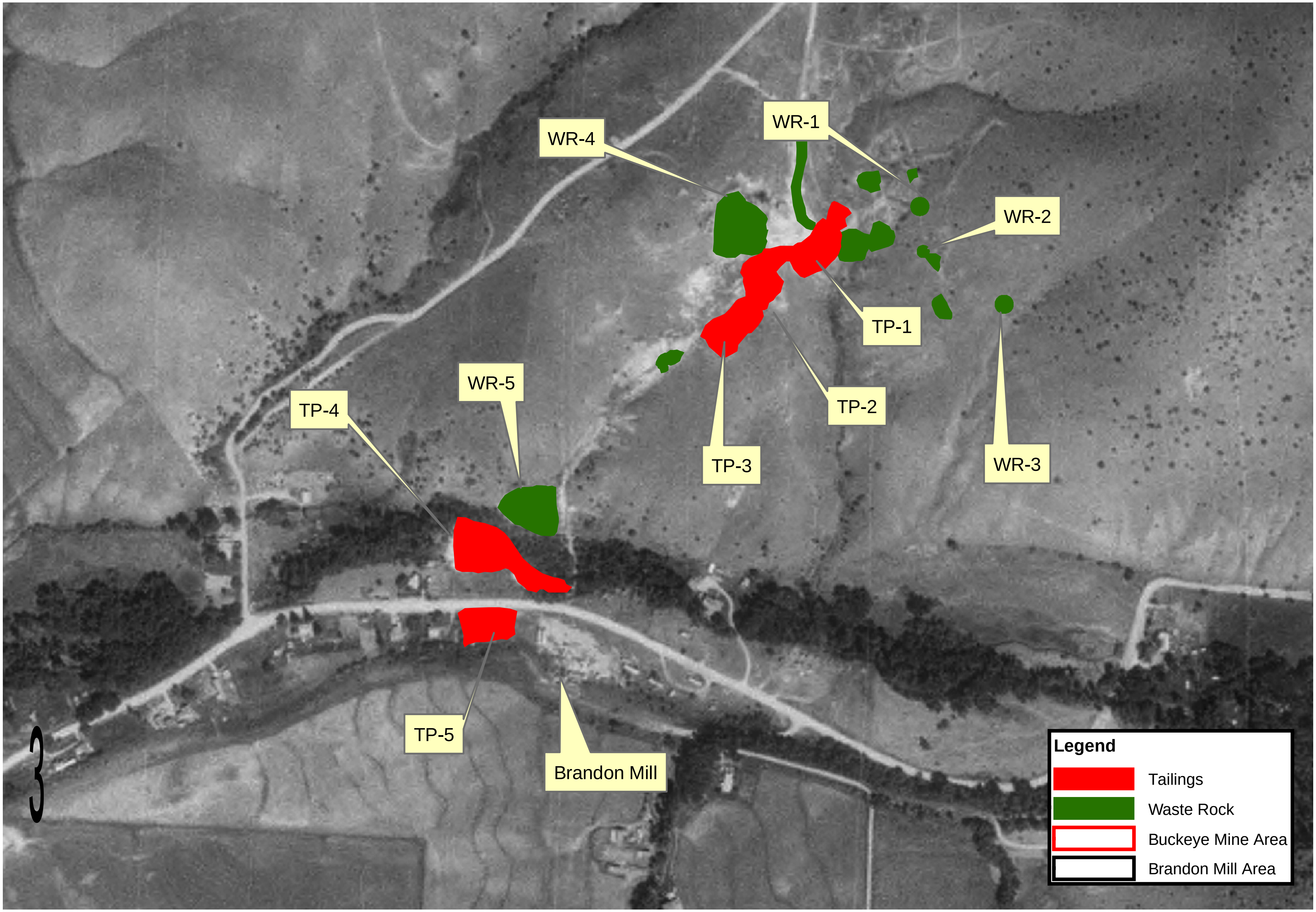
Figure 1-1
Site Location Map

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0 400 800 Feet

Figure 1-2
Aerial Photograph of the
Buckeye Mine Area

- Summary of Contaminant Exposure Pathways, and
- Potential Borrow Source and Repository Site Investigations.

## 1.1 REPORT ORGANIZATION

The Expanded EE/CA report is organized into 11 sections. The contents of each section are briefly described below and on the following pages:

**SECTION 2.0 BACKGROUND -** presents a background description of the Buckeye Mine project's significant site features including: a detailed history of past mining and milling activities; geologic, hydrologic, and climatic characteristics of the site; the biological setting, such as the wildlife and fisheries resources and the vegetation indigenous to the area; threatened and endangered species concerns; and the cultural setting issues, such as present and future land uses, are described in this section.

**SECTION 3.0 WASTE CHARACTERISTICS AND SUMMARY OF THE SITE CHARACTERIZATION -** presents the results of the Site Characterization Report which describes the characteristics of the wastes present at the site, including types, volumes, and contaminant concentrations. The impact to groundwater, surface water and stream sediments, an assessment of airborne particulate emissions and the results of the potential repository site investigations are also described in this section.

**SECTION 4.0 SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS -** presents the Montana Federal and State government requirements which are considered applicable or relevant and appropriate (ARAR) for the reclamation effort. Requirements discussed in this section are chemical-, location-, and action-specific ARARs.

**SECTION 5.0 SUMMARY OF RISK ASSESSMENT -** presents the risk analysis performed for the site. Potential sources, routes of exposure, and potential receptors are evaluated to determine the relative threats posed by each potential source within the project boundary. This evaluation is incorporated into a baseline Human Health Risk Assessment and an Ecological Risk Assessment.

**SECTION 6.0 PRELIMINARY RECLAMATION GOALS -** presents the reclamation objectives and applicable clean-up standards. Where appropriate, these objectives specify contaminants of concern (CoCs), media affected, exposure pathways, and preliminary reclamation goals (PRGs) for each environmental medium. PRGs are numerical values based on identified chemical-specific ARARs. PRGs are developed based on both ARARs and the results of the Risk Assessment activities.

**SECTION 7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES -** identifies and screens potentially applicable reclamation alternatives. Reclamation alternatives are evaluated based on effectiveness, implementability, and cost.

**SECTION 8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES -** presents a detailed analysis and comparison of the final screened alternatives against the National Contingency Plan (NCP) evaluation criteria. This includes a qualitative evaluation of threshold criteria, and how each alternative will mitigate risk from the contamination and comply with ARARs.

**SECTION 9.0  COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES -** compares the reclamation alternatives for consistency with ARAR requirements and develops the design approach for the final reclamation of the site.

**SECTION 10.0  PREFERRED ALTERNATIVE -** proposes a preferred reclamation alternative for the final reclamation activities at the site.

**SECTION 11.0  REFERENCES -** lists the references cited in the text.

# 2.0 BACKGROUND

Background information for the Buckeye Mine site is summarized in the following sections:

- Mining History
- Climate
- Geology, Hydrogeology, and Hydrology
- Current Site Setting

## 2.1 MINING HISTORY

The Sheridan mining district includes all mining properties on the west slope of the Tobacco Root range from Wisconsin Creek south to California and Bivins Gulches inclusive (Tansley, et al., 1933). The mining properties and the Brandon Mill located in the Mill Creek drainage are considered part of the Sheridan mining district. Early development in the Sheridan region closely followed the discovery of gold in Alder Gulch in 1863.

The following discussion is taken directly from the historical narrative summary of the Sheridan mining district and the Buckeye mine compiled by the Montana Department of Environmental Quality (MTDEQ, 2003). Alfred Cisler, one of the first settlers of the town of Brandon, discovered the Buckeye mine in the 1860s. The Brandon mill was the first mill to be erected in the Sheridan district. The mill was constructed in 1865, had 12 stamps of 500 pounds each and processed 12 tons of ore per day. Mill production in the early years was limited due to the use of water power to drive the stamps.

The Buckeye property is composed of five locations on the same vein and three of the group were patented: the Buckeye, the Buckeye #1, and the Buckeye #5. The claims were formally located in January of 1883 and were surveyed for patent in March of 1896. Henry Elling, Virginia City general store owner turned mining magnate, owned the property at the time of the survey which listed $3,930 in tunnels, shafts, and levels. Figure 2-1 shows the generalized land ownership and mining claims in the vicinity of the site.

The Buckeye claims showed surface mineralization their entire length of the 600 foot vein. When George Cope visited the site in the mid 1880s, he noted that the entire surface could be mined with a scraper and run through concentrating jigs. To dig anywhere on the claim was to find ore. He predicted the true value of the mine was as a large producer of low-class ore (Cope, 1888).

In 1896 the property, which was owned by Henry S. Gilbert et al., was one of the three best developed mines in the district, and was being developed by David Fifer of Butte, who took a lease and a bond on the mine. By 1898, Fifer had excavated the shaft to 70 feet where he struck a fine vein of galena and carbonate ore. The shaft, which was sunk entirely in ore, dropped to the 100 foot level before developing a system of levels and cross cuts. In May of 1898, Fifer began to run the concentrator in Brandon entirely on Buckeye ore. In July, he freighted 35 tons of galena to Twin Bridges to be shipped by rail to the smelter in East Helena (Western Mining World passim).

The mine continued to be developed by a series of lessees. In 1899, O.S. Brooks and John Merrill leased the mine and were reported to be taking out good ore. In March of 1900,

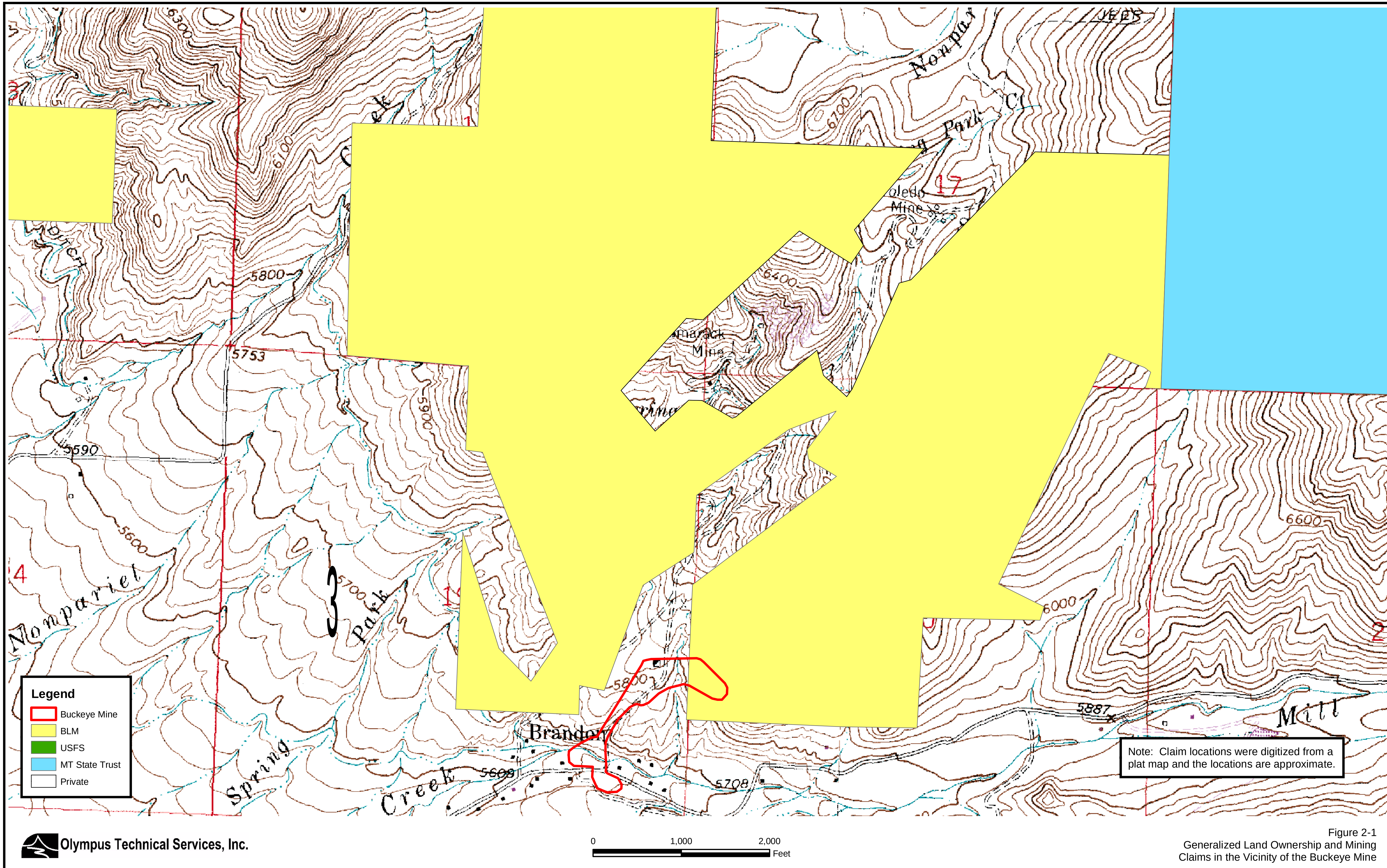



Figure 2-1
Generalized Land Ownership and Mining Claims in the Vicinity of the Buckeye Mine

Cavanaugh and McDonald leased the property and sent ore to the Twin Bridges Smelter. Later the same year Wiseman and Co. shipped ore from the mine to East Helena. Although the mine was listed as one of the district's most developed in 1902, the mine saw little further work until 1919 (Western Mining World passim).

Interest was renewed in the mine in 1916 when it was listed in the Mineral Record as a key producer in the district. However, production did not resume until 1919 when several lots were shipped from the mine. The next year it briefly resumed its role as one of the district's largest producers before shutting down in 1921. In 1924, development resumed under the recently organized Buckeye Corporation as several lots of sulfide ore were shipped from the mine. In 1925, the mine's lessees shipped lead-zinc ore to the Timber Butte plant in Butte. Although the mine was only active for 30 days, it was the district's leading producer and the lessees opened up a large body of ore. The 1926 season saw the mine still under lease and shipping ore to the Timber Butte Plant from January to March. Although the Buckeye Corporation ended its active role in the operation of the mine in 1927, new lessees shipped several cars of lead-zinc ore to Butte in 1928. By 1929, the mine had risen to become the chief producer in the district (Mineral Record, 1916 - 1929; Trauerman, 1950).

In 1929, the Vigilante Mining Corporation (VMC) began serious development of the property. Organized in August of 1929 with Texas capital and with A.H. Dahle as President, the company was reported to be remodeling the mill at the Buckeye (probably the Brandon Mill). A 75-ton concentrating table and flotation plant was ordered from the Butte Machinery Co. and installed by September. By October, VMC was reported to be working the mine dump and by the end of the year had reduced 2,648 tons of material to 344 tons of lead concentrate. In addition, several cars of lead-zinc were shipped to Butte. In 1930, the mine was listed as one of the chief producers of lead in Montana. Operations, including both the Brandon Mill and the lead-zinc ore shipments to Butte, were suspended in June of 1930 (Mining Truth 1929; Mining Journal 1929; Mineral Record 1929; 1930).

Because the Stock Market crash of October 1929 and the following Great Depression reduced both mining speculation and the government's ability to report on mineral production, the mine disappeared from both the trade journal and government reports. In 1933, Wilfred Tansley described the mine's development as two adits which had been extended over 600 feet on the vein. He noted that a portion of the Buckeye ore body was stoped and the ore concentrated at the Buckeye Mill. He also reported that the collapse of mineral prices had brought an end to production (Tansley, et al., 1933).

Yet with a huge body of low-grade ore, the mine continued to interest developers. From 1944 to 1948, the Buckeye Corporation leased the property to Victoria Mines, Inc. who operated the mine. The mine and mill were most recently operated by Steve Mortensen until 1983. The mine was worked with front-end loaders, loaded into trucks, crushed with a ball mill and the concentrate was shipped to East Helena for final treatment.

## 2.2 CLIMATE

There are no official weather stations in the Mill Creek drainage. The nearest official weather stations to the Buckeye Mine are located in Twin Bridges and Virginia City, Montana. National Oceanic and Atmospheric Administration's Western Regional Climate Center has compiled temperature and precipitation data at Twin Bridges (248430) and Virginia City (248597), Montana for the periods June 1, 1950 through December 31, 2002 and July 1, 1948 through December 31, 2002, respectively.

These appear to be the closest official weather stations to the Mill Creek drainage. Twin Bridges and Virginia City are approximately 12 miles northwest and 16 miles southeast of the Buckeye Mine site, respectively. The average annual maximum and minimum temperatures recorded at the Twin Bridges site were 58.3 degrees Fahrenheit (°F) and 27.9°F, respectively. The average annual maximum and minimum temperatures recorded at the Virginia City site were 55.2°F and 29.2°F, respectively. The average annual total precipitation for the Twin Bridges and Virginia City sites is 9.57 and 15.64 inches, respectively. The lowest and highest average precipitation occurs in the months of January/February and May/June, respectively. Average annual total snowfall is 10.3 and 63.8 inches for Twin Bridges and Virginia City, respectively. Most snow falls from November through April.

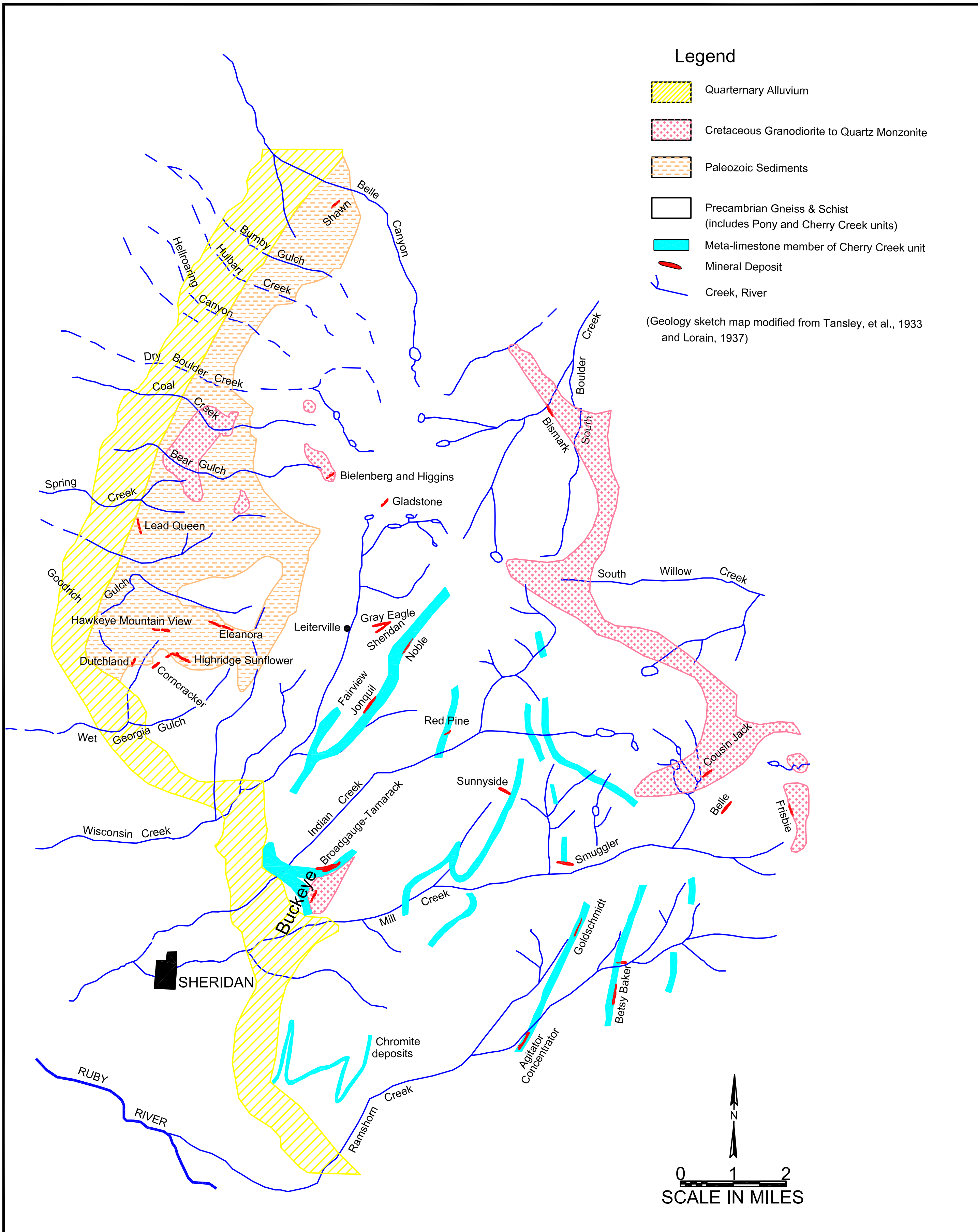
Like most of southwestern Montana, the Mill Creek drainage is subject to a cool and dry continental-dominated climate. The temperature of the region is marked by wide seasonal and daily variations. During winter, the temperature can fall lower than 30 degrees below zero Fahrenheit. During summer, many days reach the 80's and 90's but due to the generally arid climate and lightness of the mountain air, the temperature can drop substantially at nightfall. Stormy weather usually brings the first snow during September, however, these "equinoctial storms" are generally succeeded by several weeks of fair weather. By November, the area is usually blanketed with snow. Heavy snows are frequent in the winter as are periods of melting and freezing which occur as a result of warm Chinook winds that occasionally blow from the west.

## 2.3 GEOLOGY, HYDROGEOLOGY, AND HYDROLOGY

The geologic mapping available for the southwestern portion of the Tobacco Root Mountains is generally limited to reconnaissance scale. A preliminary geologic map of the Dillon 1°x2° quadrangle was prepared by Alt and Hyndman (1978). This small scale map summarized earlier reconnaissance mapping completed by others. The reconnaissance geologic mapping completed by Tansley, et al. (1933) provides the most detail relative to the geologic setting of greater Sheridan mining district area which hosts the Buckeye Mine site. A geologic sketch map (Figure 2-2) modified from Tansley, et al. (1933) and Lorain (1937) depicts the general geology, known mineral deposits and drainage pattern in the greater Sheridan Mining district, which includes the Sheridan and Tidal Wave mining districts.

The principal country rocks of the Sheridan mining district are the Precambrian metamorphic rocks identified as the Cherry Creek and Pony gneisses and schists. These metamorphic rocks are the oldest rock units in the area and the Pony gneiss is believed to be older than the Cherry Creek gneiss. The contact between the Pony and Cherry Creek units is generally not distinct and these units have not been differentiated in the geologic map presented in Figure 2-2.

According to Reid (1957) who completed more detailed mapping in the northern portion of the Tobacco Root Mountains, differentiation of the two units can only be made by observing the intermixed layers over a 500 to 1,000 feet section. The principal metamorphic rocks in these units include leptite, gneiss and amphibolite. The Cherry Creek unit contains similar main layers of leptite, gneiss and amphibolite, but is characterized by intermixed layers of marble (meta-limestone), thick greenish quartzite, sillmanite schist or coarse garnet amphibolite. Tansley, et al. (1933) noted that the occurrence of limestone in the Cherry Creek unit is more extensive in

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Geologic Sketch Map
Greater Sheridan Mining District Area

FIGURE
2-2

this region than anywhere else in the Tobacco Root Mountains and these limestones have been important in localizing orebodies. The Cherry Creek gneiss appears to be the dominant Precambrian metamorphic unit in the Sheridan mining district based on the more widespread occurrence of meta-limestone. Paleozoic sedimentary rocks, consisting of quartzites, shales and limestones, generally occur along the boundary area of the Tobacco Root Mountains. In the greater Sheridan mining district area, Paleozoic sedimentary rocks are present only in the northwestern portion. The principal intrusive rock in the Tobacco Root Mountains is a Cretaceous-age batholith comprised predominantly of granodiorite and lesser quartz monzonite (Reid, 1957). The batholith is generally an even-grained to porphyritic, massive light-gray rock composed of plagioclase, quartz, and microcline with minor biotite and hornblende. Zircon, allanite, magnetite, sphene and apatite are the principal accessories. In the greater Sheridan mining district area, the western edge of the Tobacco Root Mountain batholith occurs in the higher elevations in the area of the headwaters of Indian and Mill Creeks. Smaller plutons, possibly apophyses of the batholith, are present in the district (Figure 2-2), as are felsic and mafic sills and dikes. Some of these sills and dikes show a spatial relationship to some of the ore deposits identified in the greater Sheridan mining district (i.e., Strawn, Noble, Dutchland, Corncracker). The youngest geologic unit in the area is Quaternary alluvium which forms creek and river deposits and valley terrace deposits.

Few details are available on the structural geology of the greater Sheridan mining district area. The contorted meta-limestone beds in the Cherry Creek gneiss indicate that the Precambrian rocks have been subjected to considerable compressional tectonics resulting in folding. Most orebodies in the district appear to be related to extensional tectonics that have produced fault and shear zones.

The reports by Tansley, et al. (1933) and Lorain (1937) provide information on the economic geology and individual mine sites. The following discussion is based principally on these references. The chief primary minerals of the greater Sheridan district are pyrite, arsenopyrite, chalcopyrite, sphalerite, and galena, all in a gangue of quartz and rarely siderite. The sulfide minerals vary in concentration from one mine to the next in the district and generally do not show any significant mineral zoning pattern. The Sheridan and Tidal Wave district deposits are predominantly lead and zinc with lesser precious metals. The highest ratio of silver to gold and most of the silver-bearing sulfides are found in the veins of Virginia City, Sheridan, Tidal Wave and Renova districts.

The veins are mainly of the fissure filling type, but in the Sheridan district, limestone replacements are of great importance. Thus, the ore-shoots of the Red Pine, Sunnyside, Smuggler, Fairview, Tamarack, Broadgauge, Betsy Baker, Goldsmith, Agitator, and many others are within or are controlled by Precambrian limestone members. The orebodies are both concordant and discordant to banding in the metamorphic rocks. In general, the veins are not related to strong structural fissures, and movement is relatively small. According to Tansley, in 1933, some of the larger veins that appeared to be associated with structural zones were observed at the Lake Shore, Gray Eagle, Noble, Fairview, Sunnyside, Smuggler, Buckeye (in granodiorite), and Betsy Baker mines.

Fissure veins occupy bedding plane faults in limestone and a few, in other sedimentary rocks. The veins in limestone may or may not be accompanied by replacement of the wallrock. Oreshoots are frequently pipelike or very irregular; their strength appears to depend upon the strength of shearing. The deposits are hosted predominantly within the Precambrian gneisses, but some are contained exclusively in the Paleozoic sedimentary rocks (i.e. Tidal Wave district) or in the granodiorite to quartz monzonite intrusive rocks (i.e. Buckeye, and Cousin Jack deposits). The Buckeye, Smuggler and Corncracker mine ores consist of impregnations and veins of heavy sulfides along crushed and sheared zones in igneous intrusives or gneiss. The orebodies in the Broadgauge-Tamarack mine are impregnations and replacements along a strong sheared and crushed zone in limestone.

The intensity of wallrock alteration in the Sheridan district varies greatly in the different deposits. Alteration associated with the vein deposit host rocks at the Gray Eagle, Fairview, Broadgauge-Tamarack, Buckeye, Sunnyside, Smuggler, and Betsy Baker generally consists of sericitization and silicification. The host rocks in these deposits also show rather strong fissuring. Also in the Broadgauge-Tamarack deposit, a light, cellular, siliceous sinter-like mass containing alunite and fine gold is developed after limestone. Most of the mining in the district has been conducted in near surface oxide-rich zones that appear to show some secondary enrichment for precious metals, especially gold. It has been reported that the important production from the Noble, Gray Eagle, Agitator, Belle and many others was probably derived from the enriched concentrations of gold in the oxidized, upper sulfide zone. The normal gold content of the hypogene or primary sulfide zone is reported to be considerably less than the oxide zone.

### 2.3.1 Local Geologic Setting

Few details are available on the geology of the Buckeye Mine. Tansley, et al. (1933) provides a summary of the mine geology and mineralization. The mine is opened by two adits, the lower of which has been extended more than 600 feet as a drift on the vein trending N30°E and dipping 20° to 35° W. During 1933, the Buckeye mine to date was developed entirely within the igneous intrusive Brandon granite (granodiorite). The vein is hosted in a shear zone within the granodiorite and the contact between the granodiorite and the Cherry Creek gneiss lies roughly parallel to the vein zone, and is only 70 to 80 feet in the hanging wall of the vein. The Buckeye fissuring is quite strong and comprises a series of strong faults throughout some 30 feet or more in width. The mineralization is of the replacement type and consists of auriferous pyrite, argentiferous galena, sphalerite, and chalcopyrite disseminated with quartz throughout the wide fissure zone. Alteration has been intense as sericitization and silicification, and sulfides in the near surface are almost completely oxidized. According to Tansley, et al. (1933), a portion of the Buckeye orebody was stoped and concentrated at the Buckeye mill as recently as the 1930's, and was stopped due to the collapse of metal prices.

### 2.3.2 Hydrogeology

Based on a review of standard hydrogeologic literature sources, no published hydrogeologic information specific to this area has been prepared. The interpretation of hydrogeologic conditions presented here is based on accepted hydrogeologic principals, local observations and available geologic information. The Buckeye Mine waste sources are located within the drainage basin of Mill Creek, a tributary to the Ruby River.

The hydrogeologic system contains two main components, bedrock and alluvial valley fill. The bedrock is comprised of metamorphic and igneous rocks that are moderately fractured and contain vein structures. The vein structures are associated with the intrusion of a granitoid pluton and older fractures related to folding and faulting of the Precambrian metamorphic rocks. Other potential bedrock controls on groundwater movement include pre-metamorphic bedding structures, unconformities, and joints. Due to the complex and unpredictable nature of the bedrock structures, it is likely that the rate and direction of groundwater flow is widely variable over short distances. Permeability and transmissivity of the bedrock aquifer system probably vary widely. The alluvial deposits are thin, shallow, and discontinuous and likely transmit both surface water from local streams and discharging bedrock groundwater.

Groundwater flow likely follows local stream gradients and topography, with groundwater discharging to gaining alluvial streams which is typical of mountain drainage systems. However, local bedrock fault systems and secondary solution features associated with meta-limestones probably exert significant control on the direction and rate of groundwater flow, as do the underground workings associated with the mines in the area.

### 2.3.3 Surface Water Hydrology

The Buckeye Mine occurs within the Mill Creek drainage (Figure 2-3). The site is located approximately 11.3 miles above the confluence of Mill Creek and the Ruby River. Tailings TP-4 and waste rock WR-5 piles are adjacent to the banks of Mill Creek. The Brandon Mill is located on the south side of Mill Creek, near tailings pile TP-4. Tailings piles TP-1 through TP-3 and waste rock piles WR-1 through WR-4 are located above the Mill Creek floodplain near an unnamed, ephemeral tributary. Mill Creek discharges into the Ruby River approximately 11.3 miles below the lower-most tailings pile (TP-5).

The peak discharges for Mill Creek in the vicinity of the Buckeye Mine were estimated using regional flood-frequency equations (Omang, 1992) and are presented in Table 2-1. The flood-frequency equations for the southwest region of Montana are based on the drainage area (23.85 square miles) and the percentage of the basin area that is above 6,000 feet in elevation (97.47 percent).

In the area above the site, Mill Creek flows through a narrow valley with steep side slopes. At Brandon, Mill Creek emerges from the narrow valley and flows over an alluvial fan until it reaches the Ruby Valley, approximately 5.5 miles northwest of Sheridan. The average stream gradient through the site area is approximately 3.4 percent. The average stream gradient above the site is approximately 6.4 percent. The average stream gradient on the alluvial fan below the site is approximately 2.3 percent.

## 2.4 CURRENT SITE SETTING

### 2.4.1 Location and Topography

The Buckeye Mine is located in the Sheridan Mining District, Madison County, Montana. The site is located within the E½, SE ¼ of Section 19 and the NW¼, SW¼ Section 20, Township 4 South and Range 4 West, Montana Principal Meridian and the latitude and longitude are North 45° 28' 25" and West 112° 8' 10”. The site is located in the Mill Creek drainage. The elevation of the site ranges from approximately 5,630 feet where Mill Creek flows through the site to 5,825 feet at the upper end. The topography of the basin is mountainous and is mostly forested. The peaks in the headwaters of Mill Creek (Branham Peaks) rise to over 10,200 feet. Branham Lakes, a pair of lakes at an elevation of approximately 8,800 feet, are formed in a cirque near the headwaters of the drainage. The town of Brandon is located on the eastern edge of the alluvial fan above the Ruby Valley. The land is used for wildlife habitat, livestock grazing, and recreation. The town of Sheridan is located approximately 3 miles west-southwest of the site.

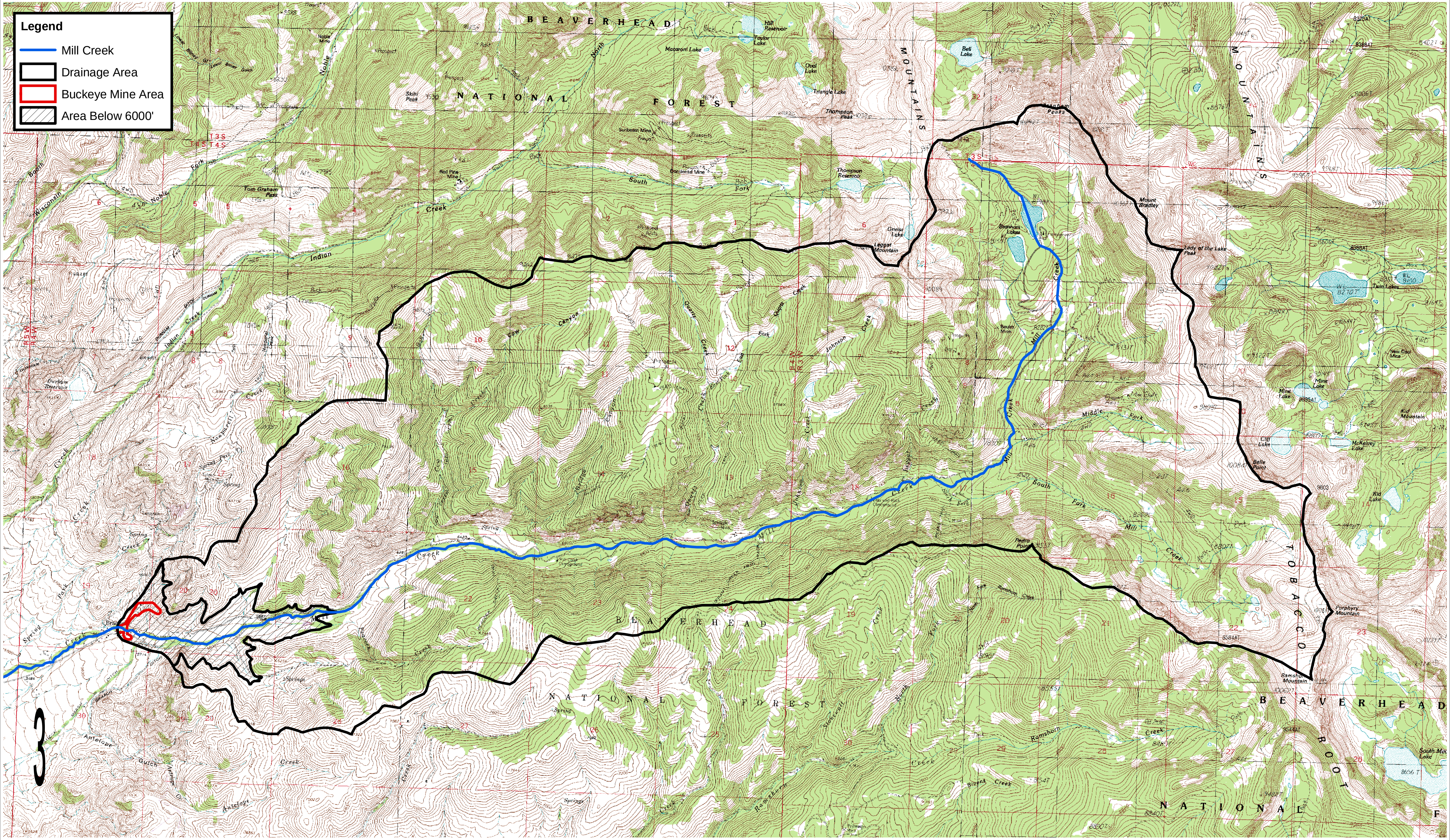


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Figure 2-3
Mill Creek Drainage Area Map

**TABLE 2-1. ESTIMATES OF PEAK DISCHARGE FOR MILL CREEK AT THE BUCKEYE MINE**

| Recurrence Interval (years) | Peak Discharge (cfs) by Regional Flood-Frequency Equations |
|---|---|
| 2 | 95 |
| 5 | 158 |
| 10 | 217 |
| 25 | 295 |
| 50 | 352 |
| 100 | 412 |

### 2.4.2 Vegetation/Wildlife

The Final Environmental Impact Statement for the U.S. Forest Service (USFS) Tobacco Root Vegetation Management Plan (USFS, 2001) describes the vegetation cover in the southern Tobacco Root Mountains as grassland, sagebrush, and juniper with scattered patches of Douglas-fir on lower elevation slopes. The mid-elevation zone is forested, dominated by Lodgepole pine, Douglas-fir, and Engelmann spruce. Higher elevations are dominated by Whitebark pine, subalpine fir, alpine grasslands, rocks, and scree. The Buckeye Mine site would be included in the lower elevation slopes.

The presence of Europeans has affected wildlife species and their habitat (USFS, 2001). Europeans initiated mining, timber harvest, grazing, road building and fire suppression. This led to an age class distribution of plant communities across the landscape that is generally older than would have existed before European influence. Indicator wildlife species in the Tobacco Root Mountains include: elk for big game species, sage grouse for sagebrush communities, pine marten for old growth spruce-fir, goshawk for old growth Douglas-fir and trumpeter swan for marshland communities. Threatened and endangered species that can be found on the Madison District of the Beaverhead-Deerlodge National Forest are the threatened grizzly bear and bald eagle (proposed for delisting), nonessential experimental gray wolf, threatened Canada lynx, and proposed threatened mountain plover. Currently in the Tobacco Root Mountains, there are no bald eagle nests, no mountain plovers, and only occasional sightings of grizzly bears, gray wolves, and lynx (USFS, 2001). Sensitive species that are known to occur in the Tobacco Root Mountains are the wolverine, northern goshawk, and black-backed woodpecker. The Tobacco Root Mountains provide habitat for mule deer, whitetail deer, antelope, elk, moose, mountain goat, black bear, and mountain lion (USFS, 2001).

The Montana Department of Fish, Wildlife and Parks (MDFWP) fisheries information contained in the Montana Fisheries Information System (MFISH) database (MDFWP, 2004) indicates that Mill Creek is 20.2 miles long and has the following Fisheries Resource Values (FRV):

| | Fisheries Resource Values (FRV) | | |
|---|---|---|---|
| River Miles | Habitat Class | Sport Class | Final Value |
| 0.0 to 1.0 | 4 | 3 | Substantial |
| 1.0 to 18.5 | 6 | 5 | Limited |

FRV: 3-Substantial; 4-Moderate; 5-Limited; 6-No Data

According to the MFISH database, Brook Trout are year-round residents and are considered common in abundance from river miles 0 to 1.0. Rainbow Trout are year-round residents and are considered rare in abundance from river miles 0 to 1.0. Based on the data quality descriptions provided, it appears that no surveys have been completed in the stream area. The data are listed as being based on professional judgment.

The MFISH database lists Mill Creek as a chronic dewatering area of concern from river mile 1.0 to 7.0. MFISH database lists a year-round instream flow protection/quantification flow of 10 cfs from river mile 0.0 to 19.7 (mouth to Branham Lake outlet). Instream flow rights and reservations are provided by Murphy Rights (passed 1969, Section 89-801 (2), RCM 1947) and the Montana Water Use Act (passed 1973, Section 85-2-316, MCA).

### 2.4.3 Historic or Archaeologically Significant Features

A Cultural Resources Inventory and Assessment was completed for the Buckeye Mine and Mills in November 2003 by Frontier Historical Consultants (Frontier, 2003). The study examined the site to determine: 1) what, if any, cultural resources were in the project area and 2) the significance of the identified resources in terms of the National Register of Historic Places.

One historic site was identified: the Buckeye Mine and Mills site (24MA1314), located at the lower end of Mill Creek Canyon, about three miles upstream from the town of Sheridan in Madison County. The mine site has a headframe, several structures, a historic mill and a modern mill area. Numerous adits and waste rock dumps dating from a century of intermittent mining and milling operations from the 1880s to the 1980s are scattered over the site area. The site includes portions of two mine patents: the Buckeye and Buckeye No. 2; a parcel of BLM land once claimed as the unpatented Lone Tree mining claim; and two tracts of unpatented land at the old community of Brandon, known as the "concentrator lot" and "tailing dump lot."

Natural and man-made forces have seriously eroded the integrity of the Buckeye Mine and Mills site. In addition, recent operations at the site have resulted in the removal, alteration or destruction of several historic structures. The other remaining features are not historically significant. Because of its greatly diminished integrity, the site does not qualify for the National Register of Historic Places as either a mine site or as a historic landscape.

Although the Buckeye Mine was one of the active mining sites in the Sheridan Mining District, albeit a minor one, the site's contribution to the Sheridan Mining District cannot be evaluated. The district's boundaries have not been defined. It has not been inventoried nor has its integrity and significance been assessed. As such the Buckeye Mine and Mills' contribution to a historic Sheridan Mining District cannot be made at this time.

### 2.4.4 Land Use and Population

Land use in the site area has historically been a mining district. The area does provide some dispersed recreational use for hunters and fishermen. The nearest population to the site area is the town of Brandon, which is located immediately south and west of the site. One residence is located immediately downstream (west) of tailings pile TP-4. There are also several residences directly across Mill Creek Road from the lower portion of the site.

The site is located near the southern end of the Tobacco Root Mountains, which provide many recreational uses. The Tobacco Root Mountains are surrounded by the Madison, Jefferson, and Ruby Valleys. Land in the valleys is privately owned and generally under agricultural production. The foothills are a mixture of private property and public lands managed by the Bureau of Land Management and State of Montana. Generally, the foothills are managed as native rangelands with scattered conifer forests. Some private property has been, and is likely to continue to be, subdivided for housing developments. Above about 6,500 feet in elevation and extending over 10,000 feet, the mountains are public land, managed by the Beaverhead-Deerlodge National Forest with scattered private in-holdings (USFS, 2001).

The Tobacco Root Mountains are a rugged mountain range with many of the high peaks along the range's backbone reaching above timberline, and they typically contain narrow and deep canyons. There are meadows and other open areas below timberline, but the majority of the area is forested. There are many small streams, several of which provide fishing opportunities, but no large streams. Mountain lakes and reservoirs are numerous and most are currently accessible by motorized vehicles of some type.

The Tobacco Root Mountains provide a wide variety of recreation opportunities. Major recreation uses include recreational driving, dispersed and developed site camping, hiking, hunting, fishing, off highway vehicle riding, horseback riding, wildlife viewing, nature study, snowmobiling, cross-country skiing, picnicking, fire wood gathering and other similar activities (USFS, 2001).

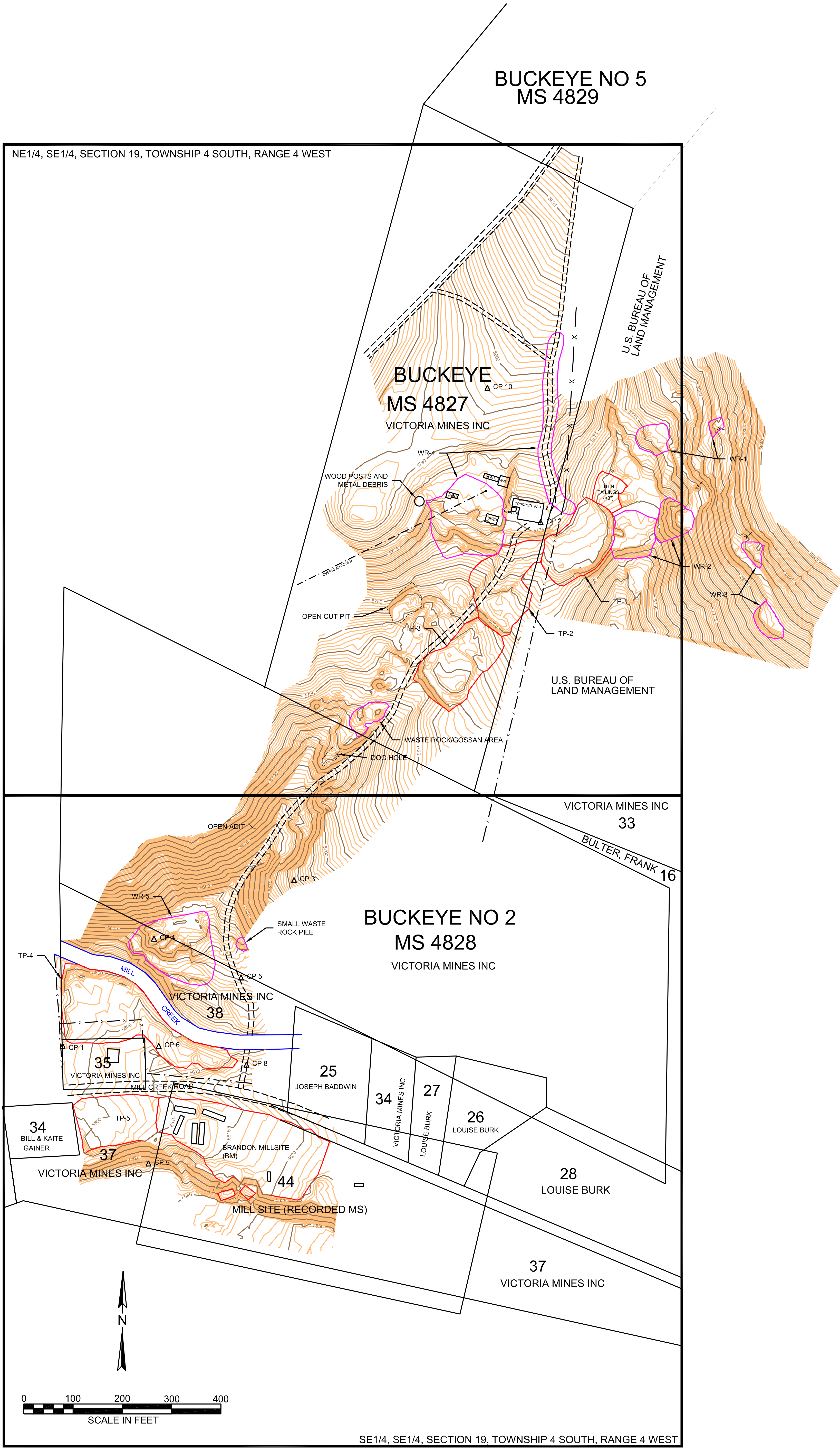
Mining activities have been common in the Tobacco Root area since the 1860's. These activities have resulted in an extensive network of low standard roads in many areas. Many of these roads are still open to either full-sized or trail vehicles and driving these roads is one of the common recreation activities in the area. Summer activities constitute the bulk of the recreation activities in the area as a whole, but the period of the most concentrated use is the first two weeks of the general big game hunting season. Winter recreational activities, such as snowmobiling and cross-country skiing, have been well established for many years. There are many miles of groomed and marked snowmobile trails and many more miles of other routes regularly used by snowmobilers and skiers (USFS, 2001).

### 2.4.5 Land Ownership

Land ownership in the area of the Buckeye Mine site was compiled by Thompson and Associates in the Fall of 2004. Table 2-2 provides a summary of the land ownership in the area of the Buckeye Mine site waste sources and Figure 2-4 shows the location of the parcels.

**TABLE 2-2. SUMMARY OF BUCKEYE MINE SITE LAND OWNERSHIP**

| Parcel | Owner Name |
|---|---|
| Buckeye MS# 4827 and Buckeye No. 2 MS# 4828, located in Section 19, Township 4 South and Range 4 West | Victoria Mines, Inc. c/o John Naisbitt, 1028 2nd Ave., Kalispell, MT 59901 |
| #35, #37, and #38, located in Section 19, Township 4 South and Range 4 West | Victoria Mines, Inc. c/o John Naisbitt, 1028 2nd Ave., Kalispell, MT 59901 |
| #44 Mill Site (Recorded MS) located in Section 19, Township 4 South, Range 4 West | Ownership not clear but believed to be Victoria Mines, Inc. c/o John Naisbitt, 1028 2nd Ave., Kalispell, MT 59901 |
| U.S. Bureau of Land Management located in Sections 19 and 20, Township 4 South and Range 4 West | Dillon Field Office, Bureau of Land Management, 1005 Selway Dr., Dillon, MT 59725 |




| Olympus Technical Services, Inc. | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE SITE<br>MADISON COUNTY, MONTANA | BUCKEYE MINE SITE<br>LAND OWNERSHIP MAP | FIGURE<br>2-4 |
|---|---|---|---|

| DESIGN: | DRAWN: KSR | CHECKED: CRS | APPROVED: | DATE: 12/2004 | JOB NO: A1475 | SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg |
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## 3.0 WASTE CHARACTERISTICS AND SUMMARY OF RECLAMATION INVESTIGATION

The objective of the Buckeye Mine site characterization was to evaluate the abandoned mine/mill wastes at the site while generating a database which met the requirements necessary to complete a risk assessment and detailed analysis of reclamation alternatives. The Site Characterization Report (DEQ-MWCB/Olympus, 2005) presents the results of the reclamation investigation activities. The data generated to support the two primary tasks are summarized as follows:

Risk Assessment Data Requirements:

- Establish background soil concentrations with at least 5 background samples;
- Characterize vertical and lateral metal concentration variations in waste sources and assess the 0 to 6 inches zone for direct contact and air emission potential;
- Evaluate the physical and chemical properties of the source material that may affect contaminant migration including: pH, metal concentrations, leaching potential, acid-base accounting and particle size distribution;
- Inventory solid and hazardous waste materials on site associated with past mining;
- Characterize impacts to shallow groundwater by conducting a limited groundwater assessment;
- Assess physical hazards associated with potential open adits or shafts, pits, trenches, highwalls and dilapidated structures, etc.; and
- Assess surface water and groundwater uses and estimate other ecological uses.

Feasibility Study Data Requirements Include:

- Determine accurate areas and volumes of the contaminant source materials including mill tailings and waste rock piles;
- Contaminant concentration variations and leaching characteristics of the waste sources;
- Representative acid-base accounting characteristics of the mill tailings and waste rock;
- Determine depth of shallow groundwater in potential repository area;
- Determine hydrologic configuration of the Mill Creek channel in the vicinity of the tailings piles;
- Determine physical characteristics and dimensions of open accesses to underground mine workings;
- Identification of potential borrow source areas for cover soil;

- Assess revegetation parameters for cover soil sources including soil texture and grain size, nitrogen, phosphorus, potassium, percent organic matter, pH and conductivity; and

- Determine optional locations and soil characteristics for repository site(s).

The principal techniques used for data acquisition in this site investigation were backhoe test pits and shovel/hand auger test holes, field mapping, soil, stream sediment, surface water and groundwater sampling. Samples were collected using standard operating procedures that are contained in the Field Sampling Plan (DEQ-MWCB/Olympus, 2004a) and were analyzed according to the Laboratory Analytical Protocol (DEQ-MWCB/Olympus, 2004c). Analytical data were evaluated for quality assurance according to the Quality Assurance Project Plan (DEQ-MWCB/Olympus, 2004d). The site characterization work was completed according to a health and safety plan (DEQ-MWCB/Olympus, 2004b).

The site characterization field program included collecting solids samples for the following types of analyses:

- Multi-element X-Ray Fluorescence (XRF) screening. XRF analyses were generally completed for all solid sampling intervals. The XRF analyses determined qualitative to semi-quantitative concentrations of the following elements: As, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Rb, Sr, Zn, and Zr.

- Target analyte list (TAL) for commercial laboratory. This includes total metals and non-metals analyses following the EPA Contract Lab Program (CLP) Methods for determining the concentrations of the following elements: Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Zn. Samples were also analyzed for total cyanide and paste pH. Laboratory analyses for the TAL were all performed at Energy Laboratories, Inc. in Helena, Montana.

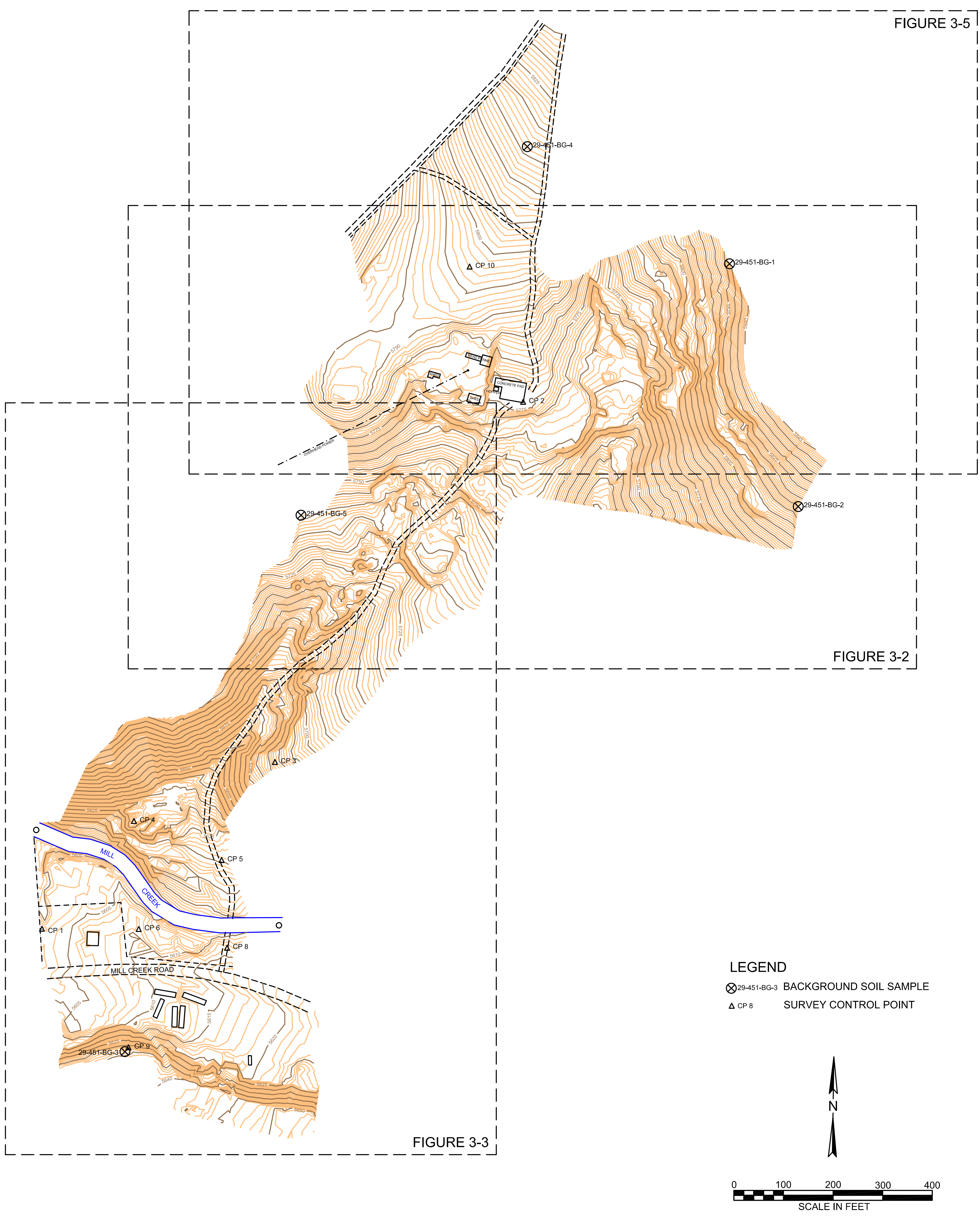
- Acid-Base Accounting (ABA) analyses including determination of sulfur fractions and neutralization potential. These analyses were all performed at Energy Laboratories, Inc. in Helena, Montana.

- Hazardous waste characteristics, determined by analysis for Toxicity Characteristic Leaching Procedure (TCLP) metals analysis for the following elements: Ag, As, Ba, Cd, Cr, Hg, Pb, and Se. These analyses were performed at Energy Laboratories, Inc. in Helena, Montana.

- Potential borrow source characteristics including analyses for particle size distribution, pH, conductivity, saturation, organic matter and content of phosphorous, nitrogen, and potassium. These analyses were performed at Energy Laboratories, Inc. in Helena, Montana.

## 3.1 BACKGROUND SOIL SAMPLES

Five background soil samples were collected from the Buckeye Mine project area. The sample locations are shown on Figure 3-1. The samples were selected to provide representative coverage of the project area outside of known waste areas and other areas of disturbance. Sample locations were selected to be representative of soils derived from the country rock present in the area of the project.




| Olympus Technical Services, Inc. | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE SITE<br>MADISON COUNTY, MONTANA | BUCKEYE MINE SITE<br>TOPOGRAPHIC MAP | FIGURE<br>3-1 |
|---|---|---|---|

| DESIGN: | DRAWN: KSR | CHECKED: CRS | APPROVED: | DATE: 4/2005 | JOB NO: A1475 | SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg |
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Background soil samples were screened for a multi-element suite using a portable XRF analyzer (Appendix A) and the same samples were analyzed at Energy Laboratories, Inc. for pH, total cyanide and the following total metals: Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb and Zn. The background soil qualitative to semi-quantitative XRF range and mean concentration results for the analyzed principal elements of interest are as follows: As (no detection), Cr (1549.6 – 1908.8 ppm and 1705.9 ppm), Cu (no detection), Fe (22,297.6 - 46,284.8 ppm and 31,458.1 ppm), Hg (no detection), Mn (no detection – 1,189.6 ppm and 826.4 ppm), Ni (1,480 – 2169.6 ppm and 1,862.9 ppm), Pb (no detection – 103.1 ppm and 50.8 ppm), and Zn (no detection - 177 ppm and 97.1 ppm). The laboratory results for the background samples are presented in Table 3-1, with the mean concentrations summarized as follows:

**Mean Background Soil Element Concentrations** (quantitative laboratory results)
**All Results in mg/kg**

| pH | Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.42 | ND | 9.0 | 152.2 | ND | 33.1 | 34.4 | 15,240 | ND | 492.6 | 22.7 | 37.5 | ND | 78.8 | NA |

*Notes: ND -No detection*
*NA - Total Cyanide was not analyzed*

## 3.2 MINE/MILL WASTE SOURCES

### 3.2.1 Tailings and Waste Rock Waste Characteristics

The site characterization report evaluated a number of mine/mill waste sources including five mill tailings and five waste rock piles. In addition, mill wastes and impacted soils were investigated in the Brandon Mill waste area. Figures 1-1 and 1-2 are a map and aerial photograph, respectively, that focus on the overall Buckeye Mine project area and illustrate the major features, including the Mill Creek drainage and the associated tailings and waste rock piles and the Brandon Mill waste area that were investigated. The general information regarding each waste source, including area (if applicable), location, average thickness (if applicable), volume, number of test locations, number of XRF samples and number of composite laboratory samples is listed in Table 3-2. The following sections summarize the results of the site characterization report for each of the waste sources.

#### 3.2.1.1 Tailings Pile TP-1 Volume, Geology and Chemistry

The tailings pile TP-1 is located in the NE¼, SE¼ Section 19, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). The tailings pile is a small side hill tailings deposit adjacent to the north-south ephemeral tributary of Mill Creek. The tailings were generated from the former millsite located in the area of the concrete pad to the northwest. Vegetation in the tailings pile TP-1 area is very sparse on top of the pile. The side slopes of the tailings pile are moderately well vegetated and this probably indicates some native soil material is present in the starter berm for the side hill deposit. The exposed tailings exhibit variable iron oxidation (FeOx) evidenced by orange brown coloration.

The TP-1 tailings volume was estimated using the detailed topographic survey of the tailings surface and the backhoe test pit data (Figure 3-2). The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005). A total volume

**Table 3-1. Background Soil Chemistry Results**

| Sample ID | Paste pH | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-451-BG1 | 7.4 | <5 | <5 | 148 | <1 | 41.9 | 40.5 | 15100 | <1 | 1000 | 25.1 | 10.8 | <5 | 36.7 |
| 29-451-BG2 | 7.5 | <5 | 7.7 | 158 | <1 | 49.9 | 36.6 | 17600 | <1 | 274 | 23.0 | 10.5 | <5 | 37.9 |
| 29-451-BG3 | 7.4 | <5 | 12.3 | 123 | <1 | 33.8 | 46.1 | 15000 | <1 | 397 | 31.1 | 105 | <5 | 157 |
| 29-451-BG4 | 7.4 | <5 | 7.4 | 159 | <1 | 21.6 | 29.5 | 15700 | <1 | 466 | 18.1 | 48.7 | <5 | 123 |
| 29-451-BG5 | 7.4 | <5 | 15.2 | 173 | <1 | 18.3 | 19.3 | 12800 | <1 | 326 | 16.3 | 12.5 | <5 | 39.4 |
| **Maximum** | 7.5 | <5 | 15.2 | 173 | <1 | 49.9 | 46.1 | 17600 | <1 | 1000 | 31.1 | 105 | <5 | 157 |
| **Minimum** | 7.4 | <5 | <5 | 123 | <1 | 18.3 | 19.3 | 12800 | <1 | 274 | 16.3 | 10.5 | <5 | 36.7 |
| **Mean** | 7.42 | 2.50 | 9.0 | 152.2 | 0.50 | 33.1 | 34.4 | 15240.0 | 0.50 | 492.6 | 22.7 | 37.5 | 2.5 | 78.8 |
| **n** | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

**LEGEND**

| | |
|---|---|
| 29-451-BG1 | Located approximately 100' up the ridge to the NE from the upper portion of waste rock pile WR1 |
| 29-451-BG2 | Located approximately 60' to the east of the southern portion of waste rock pile WR3 |
| 29-451-BG3 | Located approximately 120' to southeast up the ridge from the center of tailings pile TP5 and adjacent to survey control point CP9 |
| 29-451-BG4 | Located approximately 435' to the NE of the headframe located near waste rock pile WR4 |
| 29-451-BG5 | Located approximately 220' to west of tailings pile TP3 up the ridge |

Note: Statistics - one half the lower detection limit is used where below detection limit samples are included in the mean calculation
NA = Not analyzed

**Pioneer Technical Services, Inc. Background Sample**

| Sample ID | Paste pH | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Co (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BACKGROUND | | 16 | 89.4 | 0.8 JX | 9.4 | 25.1 | 21.6 | 14,900 | 1.1 | 366 | 19 | 36 | 4 UJ | 80 |

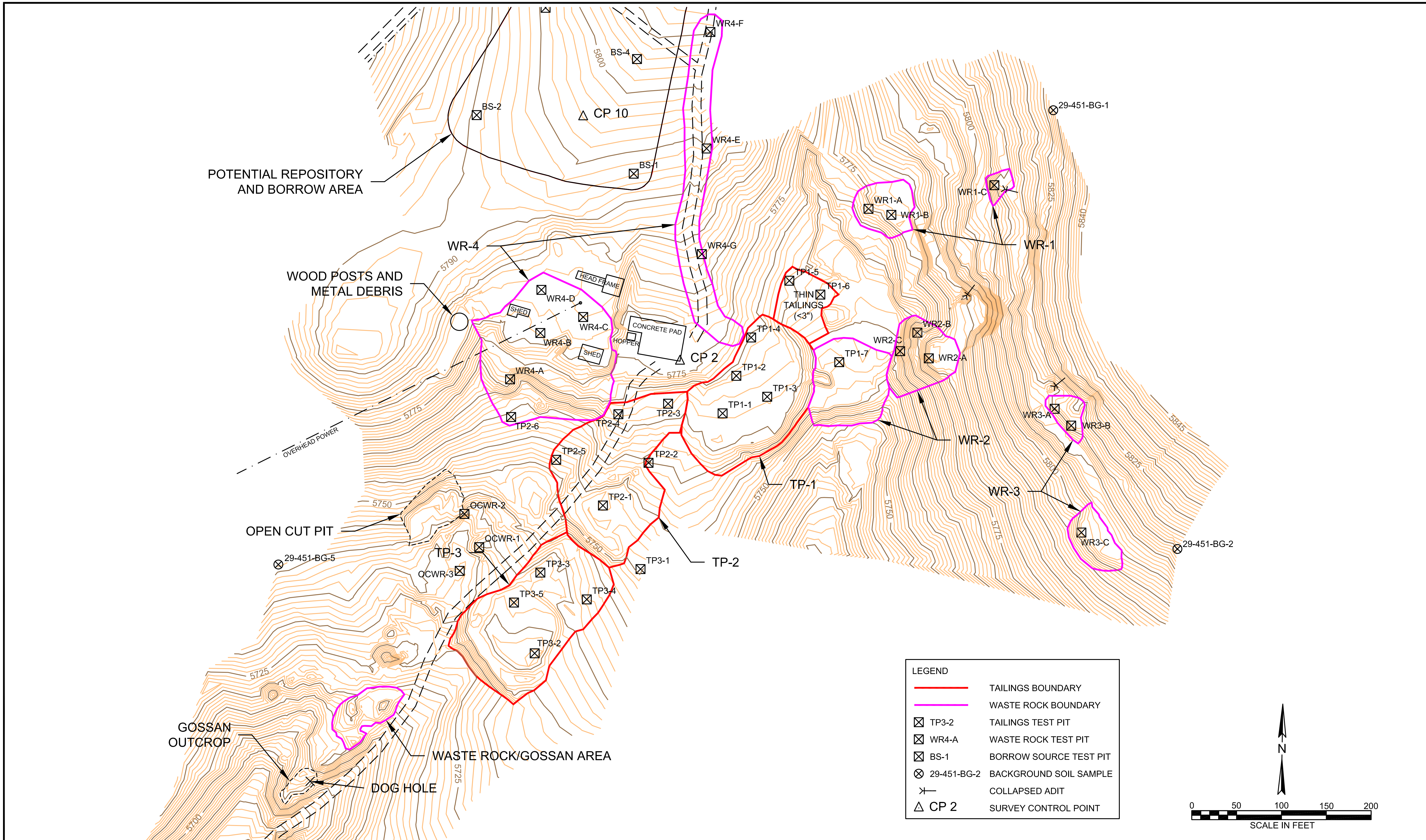
U - Not Detected; J - Estimated Quantity; X - Outlier for Accuracy or Precision; NR - Not Requested

Note: BACKGROUND collected from the Latest Out (PA # 29-354-SS-1) area for the Buckeye Mine preliminary assessment

**Table 3-2. Summary of General Information for the Buckeye Mine Site Waste Sources**

| Waste Source Identification | Area (Acres) | Location (Section, Township, Range) | Average Thickness Estimated (feet) | Waste Volume (cubic yards) | Test Locations[1] | XRF Samples | Laboratory Composite Samples |
|---|---|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | | NE¼, SE¼ Sec 19, T4S, R4W | | | | | |
| TP-1 | 0.47 | | 6.4 | 4,000 | 6 | 24 | 4 |
| TP-2 | 0.41 | | 3.4 | 2,260 | 5 | 20 | 2 |
| TP-3 | 0.36 | | 5.4 | 3,150 | 5 | 16 | 3 |
| Subtotal | 124 | | | 9,410 | | | |
| Buckeye Mine Tailings Subarea 2 | | SE¼, SE¼, Sec 19, T4S, R4W | | | | | |
| TP-4 | 0.77 | | 2.6 | 3,170 | 12 | 24 | 3 |
| TP-5 | 0.36 | | 1.6 | 900 | 5 | 10 | 2 |
| Subtotal | 1.13 | | | 4,070 | | | |
| Buckeye Mine Waste Rock Subarea 1 | | NE¼, SE¼, Sec 19 and NW¼, SW¼ Sec 20, T4S, R4W | | | | | |
| WR-1 | 0.10 | | 1.2 | 180 | 3 | 4 | 1 |
| WR-2 | 0.28 | | 2.9 | 1,269 | 3 | 4 | 1 |
| WR-3 | 0.08 | | 1.5 | 220 | 3 | 4 | 1 |
| WR-4 | 0.71 | | 2.9 | 3,730 | 5 | 13 | 2 |
| Gossan Area | 0.07 | | 1.4 | 160 | - | - | - |
| Subtotal | 1.24 | | | 5,559 | | | |
| Buckeye Mine Waste Rock Subarea 2 | | SE¼, SE¼, Sec 19, T4S, R4W | | | | | |
| WR-5 | 0.42 | | 3.4 | 2,280 | 6 | 9 | 2 |
| Brandon Mill Waste Area | | SE¼, SE¼, Sec 19, T4S, R4W | | | | | |
| BM | 0.98 | | 1.7 | 2,750 | 19 | 27 | 3 |

[1]Test locations may include one or more of the following methods: backhoe test pit, shovel test pit or hand auger boring

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MONTANA DEQ/MINE WASTE CLEANUP BUREAU
BUCKEYE MINE SITE
MADISON COUNTY, MONTANA

Olympus Technical Services, Inc.

UPPER BUCKEYE MINE SITE AREA

FIGURE 3-2

estimate for the mill tailings contained in the TP-1 area is 4,000 cubic yards (cy). The tailings plan area is 0.47 acres and the average and maximum tailings thickness are 6.4 and 12.9 feet, respectively.

The TP-1 tailings pile geology is based on observations made from 6 test holes (Figure 3-2). All of the backhoe test pits intercepted native soil. The upper zone of the tailings pile is comprised predominantly of oxidized silty sand with varying degrees of orange to yellow brown iron oxide (FeOx) coloration. The non-oxidized tailings generally consist of light brown to tan silty sand with lesser clayey silt to silty clay layers. The tailings slimes in TP-1 consist of bluish gray silty clay with lesser light green silty clay. Test pits TP1-1 and TP1-3 intersected tailings slime zones less than 3 feet thick. The TP-1 tailings are dry with the exception of slight to moderate moisture detected in the finer-grained slime zones. The native soil horizon below the tailings generally consists of dry coalluvium containing sand, gravel and rock. This material varies from dark gray to black, micaceous-rich sand to tan to light brown sand containing abundant gravel with rock ranging from 4- to 12-inch diameter. Particle size analyses for selected tailings intervals are summarized in Table 3-3. The laboratory analyses for representative samples of orange to yellow brown silty sand, light green to bluish gray silty clay and light brown silty sand from TP1 indicate that these tailings are sandy silt with 22% clay, clayey silt, and silty sand with 15% clay, respectively.

Representative samples were collected from vertical channel samples taken from the test pit wall or from grab samples collected from the test pit excavation stockpile. Individual samples were collected based on similar geologic characteristics. Seventeen tailings samples and three representative composite tailings samples were collected from the TP-1 tailings pile area for XRF screening (Appendix A). In addition, four native soil samples were collected from below the tailings near the contact zone for XRF screening. In addition, a single rock sample (TP1-ORE) was screened via XRF with questionable results. The rock sample contained visible pyrite, galena and sphalerite, although the results returned elevated iron only. The TP-1 tailings XRF concentration range results for the analyzed principal elements of interest are as follows: As (no detection - 320.8 ppm ), Cr (no detection – 3,328 ppm), Cu (no detection - 383 ppm), Fe (17,689.6 - 51,686.4 ppm), Mn (no detection - 2,560 ppm), Mo (no detection - 32.3 ppm), Ni (no detection – 7,174.4 ppm), Pb (116.7 - 2,880 ppm), and Zn (305 - 3,628.8 ppm). Mercury had essentially no detection except for a single sample that had an estimated concentration of 75.4 ppm.

Four native soil samples were collected below the tailings for XRF screening analysis. When compared to background soil and the mean element concentrations for tailings pile TP-1, the results suggest that there is some mobilization of Pb and Zn from the tailings into the native soils.

Laboratory analytical data for the four composite samples collected from the TP-1 tailings area are summarized in Table 3-4. The tailings pH is slightly acidic to alkaline ranging from 6.9 to 7.4 standard units (SU). The mean concentrations and the mean concentrations relative to background mean concentrations for analytes with greater than 50 percent of the samples reporting above the method detection limit are summarized below.

**Table 3-3. Mill Tailings Particle Size Results**

| Sample ID | Weight Percent Retained | | | | | Percent Finer by Weight | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gravel | Sand | | | Silt/Clay | Gravel | Sand | | | Silt/Clay | | | | |
| Sieve Size | 3/4-in | #4 | #10 | #40 | #200 | 3/4-in | #4 | #10 | #40 | #200 | Percent | Percent | Percent | Soil |
| Opening (Inches) | 0.75 | 0.187 | 0.0661 | 0.0106 | 0.0029 | 0.75 | 0.187 | 0.0661 | 0.0106 | 0.0029 | Sand | Silt | Clay | Texture |
| 29-451-TP1-1 | 6.5 | 9 | 7.0 | 15.7 | 19.6 | 93.5 | 84.5 | 77.5 | 61.8 | 42.2 | 36 | 42 | 22 | Loam |
| 29-451-TP1-2 | <0.1 | <0.1 | 0.1 | 0.4 | 2.0 | 100 | 100 | 99.9 | 99.5 | 97.5 | 1 | 65 | 34 | Silty Clay Loam |
| 29-451-TP1-3 | <0.1 | 1.5 | 2.8 | 10.4 | 26.7 | 100 | 100 | 97.2 | 86.8 | 60.1 | 47 | 38 | 15 | Loam |
| 29-451-TP2-1 | <0.1 | 1.9 | 3.8 | 12.5 | 19.2 | 100 | 98.1 | 94.3 | 81.8 | 62.6 | 40 | 46 | 14 | Loam |
| 29-451-TP2-2 | <0.1 | 0.3 | 3.1 | 11.2 | 17.9 | 100 | 99.7 | 96.6 | 85.4 | 67.5 | 39 | 54 | 7 | Silt Loam |
| 29-451-TP3-1 | <0.1 | 1.1 | 0.8 | 4.7 | 14.6 | 100 | 98.9 | 98.1 | 93.4 | 78.8 | 33 | 44 | 23 | Loam |
| 29-451-TP3-2 | <0.1 | <0.1 | <0.1 | 0.2 | 0.9 | 100 | 100 | 100 | 99.8 | 98.9 | 1 | 72 | 27 | Silty Clay Loam |
| 29-451-TP3-3 | <0.1 | 0.3 | 0.9 | 4.4 | 18.4 | 100 | 99.7 | 98.8 | 94.4 | 76 | 35 | 52 | 13 | Silt Loam |
| 29-451-TP4-1 | <0.1 | <0.1 | <0.1 | 6.7 | 41.2 | 100 | 100 | 100 | 93.3 | 52.1 | 52 | 27 | 21 | Sandy Clay Loam |
| 29-451-TP4-2 | <0.1 | <0.1 | <0.1 | 2.3 | 5.7 | 100 | 100 | 100 | 97.7 | 92 | 7 | 64 | 29 | Silty Clay Loam |
| 29-451-TP4-3 | <0.1 | <0.1 | 2.4 | 27.6 | 43.7 | 100 | 100 | 97.6 | 70 | 26.3 | 74 | 18 | 8 | Sandy Loam |
| 29-451-TP5-1 | <0.1 | <0.1 | 1.8 | 13.9 | 38.3 | 100 | 100 | 98.2 | 84.3 | 46 | 57 | 29 | 14 | Sandy Loam |
| 29-451-TP5-2 | <0.1 | <0.1 | 2.6 | 15.5 | 41.9 | 100 | 100 | 97.4 | 81.9 | 40 | 59 | 26 | 15 | Sandy Loam |

**LEGEND**

29-451-TP1-1 is a composite of TP1-1-0-2.8; TP1-3-0-1.6; TP1-2-0-1.7
29-451-TP1-2 is a composite of TP1-1-2.8-5.4; TP1-3-4.2-5.8
29-451-TP1-3 is a composite of TP1-2-3.7-8.0; TP1-1-5.4-9.6; TP1-3-5.8-12.9; TP1-4-3.5-8.3
29-451-TP2-1 is a composite of TP2-4-0-2.1; TP2-1-2.2-3.9
29-451-TP2-2 is a composite of TP2-2-0-5; TP2-3-0.6-4.6; TP2-5-0-4.8; TP2-6-2.1-4.9
29-451-TP3-1 is a composite of TP3-3-0-4.8; TP3-4-0-5.9; TP3-1-0-5.5
29-451-TP3-2 is a composite of TP3-2-0-1.8; TP3-2-1.8-4.9
29-451-TP3-3 is a composite of TP3-2-4.9-8.8; TP3-5-5.4-10.2
29-451-TP4-1 is a composite of TP4-1-0-3.1; TP4-2-0-2.0; TP4-7-0-1.9
29-451-TP4-2 is a composite of TP4-2-2.0-2.6; TP4-4-3.7-5.0; TP4-11-2.5-3.1
29-451-TP4-3 is a composite of TP4-3-0-2.5; TP4-5-0-2.5; TP4-6-0-3.2
29-451-TP5-1 is a composite of TP5-1-0-1.1; TP5-3-0-0.6; TP5-4-0-0.3
29-451-TP5-2 is a composite of TP5-5-0-2.5; BM15-0-1.2

**TABLE 3-4. Laboratory Chemistry Results For Mill Tailings**

| Sample ID | pH (SU) | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) | Total Cyanide (mg/Kg) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tailings Pile TP1** | | | | | | | | | | | | | | | | |
| 29-451-TP1-1 | 7.0 | 15.4 | 99.8 | 76.0 | 9.7 | 12.4 | 522 | 34100 | <1 | 605 | 18.9 | 1990 | 13.4 | 1920 | <0.5 | Composite of TP1-1-0-2.8; TP1-3-0-1.6; TP1-2-0-1.7 |
| 29-451-TP1-2 | 7.2 | 7.2 | 206 | 62.2 | 9.2 | 40.6 | 129 | 33200 | <1 | 1230 | 44.9 | 892 | <5 | 1760 | <0.5 | Composite of TP1-1-2.8-5.4; TP1-3-4.2-5.8 |
| 29-451-TP1-3 | 7.8 | <5 | 45.1 | 167 | 2.9 | 23.6 | 94.1 | 24200 | <1 | 714 | 25.0 | 281 | <5 | 494 | <0.5 | Composite of TP1-2-3.7-8.0; TP1-1-5.4-9.6; TP1-3-5.8-12.9; TP1-4-3.5-8.3 |
| 29-451-TP6-1 | 5.3 | 6.1 | 175 | 54.4 | 8.9 | 36.9 | 172 | 33000 | <1 | 1000 | 42.8 | 1140 | <5 | 1530 | <0.5 | Duplicate sample of 29-451-TP1-1 |
| **Maximum** | 7.8 | 15.4 | 206 | 167 | 9.7 | 40.6 | 522 | 34100 | <1 | 1230 | 44.9 | 1990 | 13.4 | 1920 | <0.5 | |
| **Minimum** | 5.3 | 6.1 | 45.1 | 54.4 | 2.9 | 12.4 | 94.1 | 24200 | <1 | 605 | 18.9 | 281 | <5 | 494 | <0.5 | |
| **Mean** | 6.83 | 7.80 | 131.48 | 89.90 | 7.68 | 28.38 | 229.28 | 31125.0 | | 887.3 | 32.90 | 1075.8 | 5.23 | 1426.0 | | |
| **No. Samples** | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| **Tailings Pile TP2** | | | | | | | | | | | | | | | | |
| 29-451-TP2-1 | 7.9 | <5 | 9.7 | 182 | 1.6 | 16.4 | 62.4 | 16000 | <1 | 423 | 14.8 | 109 | <5 | 394 | <0.5 | Composite of TP2-4-0-2.1; TP2-1-2.2-3.9 |
| 29-451-TP2-2 | 7.9 | <5 | 6.5 | 178 | 1.4 | 17.6 | 54.4 | 15200 | <1 | 383 | 15.2 | 97.0 | <5 | 328 | <0.5 | Composite of TP2-2-0-5; TP2-3-0.6-4.6; TP2-5-0-4.8; TP2-6-2.1-4.9 |
| **Maximum** | 7.9 | <5 | 9.7 | 182 | 1.6 | 17.6 | 62.4 | 16000 | <1 | 423 | 15.2 | 109 | <5 | 394 | <0.5 | |
| **Minimum** | 7.9 | <5 | 6.5 | 178 | 1.4 | 16.4 | 54.4 | 15200 | <1 | 383 | 14.8 | 97.0 | <5 | 328 | <0.5 | |
| **Mean** | 7.90 | | 8.10 | 180.0 | 1.50 | 17.00 | 58.40 | 15600.0 | | 403.0 | 15.00 | 103.00 | | 361.0 | | |
| **No. Samples** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| **Tailings Pile TP3** | | | | | | | | | | | | | | | | |
| 29-451-TP3-1 | 8.0 | <5 | 5.6 | 181 | 1.1 | 18.8 | 40.2 | 15000 | <1 | 396 | 17.0 | 86.5 | <5 | 189 | <0.5 | Composite of TP3-3-0-4.8; TP3-4-0-5.9; TP3-1-0-5.5 |
| 29-451-TP3-2 | 7.5 | 59.7 | 508 | 21.6 | 6.9 | 12.6 | 1430 | 51100 | <1 | 351 | 8.5 | 5510 | <5 | 324 | <0.5 | Composite of TP3-2-0-1.8; TP3-2-1.8-4.9 |
| 29-451-TP3-3 | 7.9 | <5 | 18.5 | 131 | 2.4 | 21.2 | 44.7 | 18800 | <1 | 639 | 34.7 | 118 | <5 | 412 | <0.5 | Composite of TP3-2-4.9-8.8; TP3-5-5.4-10.2 |
| **Maximum** | 8.0 | 59.7 | 508 | 181 | 6.9 | 21.2 | 1430 | 51100 | <1 | 639 | 34.7 | 5510 | <5 | 412 | <0.5 | |
| **Minimum** | 7.5 | <5 | 5.6 | 21.6 | 1.1 | 12.6 | 40.2 | 15000 | <1 | 351 | 8.5 | 86.5 | <5 | 189 | <0.5 | |
| **Mean** | 7.80 | 21.57 | 177.37 | 111.20 | 3.47 | 17.53 | 504.97 | 28300.0 | | 462.0 | 20.07 | 1904.83 | | 308.3 | | |
| **No. Samples** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |
| **Tailings Pile TP4** | | | | | | | | | | | | | | | | |
| 29-451-TP4-1 | 5.9 | 21.9 | 143 | 51.2 | 23.1 | 6.6 | 472 | 23500 | 2.3 | 478 | 13.4 | 2540 | 11.5 | 3500 | <0.5 | Composite of TP4-1-0-3.1; TP4-2-0-2.0; TP4-7-0-1.9 |
| 29-451-TP4-2 | 6.0 | 60.1 | 189 | 48.3 | 79.3 | <5 | 1980 | 38100 | 3.3 | 575 | 14.5 | 7750 | 49.9 | 12500 | <0.5 | Composite of TP4-2-2.0-2.6; TP4-4-3.7-5.0; TP4-11-2.5-3.1 |
| 29-451-TP4-3 | 7.4 | 15.5 | 338 | 32.3 | 48.2 | 19.2 | 560 | 25200 | <1 | 1310 | 34.1 | 1640 | 13.6 | 6650 | <0.5 | Composite of TP4-3-0-2.5; TP4-5-0-2.5; TP4-6-0-3.2 |
| **Maximum** | 7.4 | 60.1 | 338 | 51.2 | 79.3 | 19.2 | 1980 | 38100 | 3.3 | 1310 | 34.1 | 7750 | 49.9 | 12500 | <0.5 | |
| **Minimum** | 5.9 | 15.5 | 143 | 32.3 | 23.1 | <5 | 472 | 23500 | <1 | 478 | 13.4 | 1640 | 11.5 | 3500 | <0.5 | |
| **Mean** | 6.43 | 32.50 | 223.3 | 43.93 | 50.20 | 9.43 | 1004.0 | 28933.3 | 2.03 | 787.7 | 20.67 | 3976.7 | 25.00 | 7550.0 | | |
| **No. Samples** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |
| **Tailings Pile TP5** | | | | | | | | | | | | | | | | |
| 29-451-TP5-1 | 4.7 | 11.8 | 106 | 85.7 | 6.6 | 29.6 | 287 | 23600 | <1 | 290 | 18.6 | 1440 | <5 | 1070 | <0.5 | Composite of TP5-1-0-1.1; TP5-3-0-0.6; TP5-4-0-0.3 |
| 29-451-TP5-2 | 6.1 | 22.7 | 222 | 60.0 | 15.4 | 19.6 | 458 | 28200 | 2.5 | 575 | 22.4 | 2900 | 11.7 | 2850 | <0.5 | Composite of TP5-5-0-2.5; BM15-0-1.2 |
| **Maximum** | 6.1 | 22.7 | 222 | 85.7 | 15.4 | 29.6 | 458 | 28200 | 2.5 | 575 | 22.4 | 2900 | 11.7 | 2850 | <0.5 | |
| **Minimum** | 4.7 | 11.8 | 106 | 60.0 | 6.6 | 19.6 | 287 | 23600 | <1 | 290 | 18.6 | 1440 | <5 | 1070 | <0.5 | |
| **Mean** | 5.40 | 17.25 | 164.0 | 72.85 | 11.00 | 24.60 | 372.5 | 25900.0 | 1.5 | 432.5 | 20.50 | 2170.0 | 7.1 | 1960.0 | | |
| **No. Samples** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |

**TABLE 3-4. Laboratory Chemistry Results For Mill Tailings**

| Sample ID | pH (SU) | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) | Total Cyanide (mg/Kg) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Brandon Mill** | | | | | | | | | | | | | | | | |
| 29-451-BM-1 | 5.2 | 58.1 | 367 | 120 | 9.0 | 21.7 | 692 | 44900 | 1.4 | 220 | 18.1 | 11200 | 12.8 | 2060 | <0.5 | Composite of BM1-0-0.5; BM4-0-1.0; BM5-0-0.7 |
| 29-451-BM-2 | 3.7 | 49.9 | 295 | 109 | 5.0 | 29.3 | 505 | 37400 | 1.4 | 135 | 16.2 | 7240 | 13.7 | 1010 | <0.5 | Composite of BM7-0-1.1; BM10-0-0.9; BM14-0-0.5 |
| 29-451-BM-3 | 2.1 | 268 | 455 | 53.3 | 16.8 | 11.3 | 961 | 77000 | 2.6 | 45.8 | 13.4 | 43400 | 32.4 | 2830 | <0.5 | Composite of BM18; BM19 |
| 29-451-BM-4 | 6.5 | 57.8 | 296 | 115 | 11.7 | 23.1 | 812 | 48300 | <1 | 274 | 16.5 | 11900 | 13.4 | 2280 | <0.5 | Duplicate sample of 29-451-BM-1 |
| **Maximum** | 6.5 | 268 | 455 | 120 | 16.8 | 29.3 | 961 | 77000 | 2.6 | 274 | 18.1 | 43400 | 32.4 | 2830 | <0.5 | |
| **Minimum** | 2.1 | 49.9 | 295 | 53.3 | 5.0 | 11.3 | 505 | 37400 | <1 | 45.8 | 13.4 | 7240 | 12.8 | 1010 | <0.5 | |
| **Mean** | 4.38 | 108.45 | 353.3 | 99.33 | 10.63 | 21.35 | 742.5 | 51900.0 | 1.48 | 168.70 | 16.05 | 18435.0 | 18.08 | 2045.0 | | |
| **No. Samples** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |

Note: Statistics - one half the lower detection limit is used where below detection limit samples are included in the mean calculation

**TP-1 Tailings Mean Element Concentrations Compared to Background** (quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.8 | 131.5 | 89.9 | 7.7 | 28.4 | 229.3 | 31,125 | ND | 887.3 | 32.9 | 1,075.8 | ND | 1,426 | ND |
| *>3.1x* | *14.6x* | *0.59x* | *>15.4x* | *0.86x* | *6.7x* | *2.0x* | | *1.8x* | *1.5x* | *28.7x* | | *18.1x* | |

*Note* *Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples; ½ detection limit used for statistics*
*Total cyanide was not analyzed in background soil*
*ND – not detected above method detection limit (Sb detected in only one sample – 13.4 mg/Kg)*

The mean concentrations from the laboratory quantitative analyses on representative composite samples generally corroborate the XRF screening concentration results with the exception of Cr and Ni which were significantly higher in the XRF method. The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Pb, and Zn.

#### 3.2.1.2 Tailings Pile TP-2 Volume, Geology and Chemistry

Tailings pile TP-2 is located in the NE¼, SE¼ Section 19, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). The TP-2 tailings area is located immediately to the southwest of TP-1. The topography, test pit locations and details of the TP-2 area are presented in the map on Figure 3-2. The tailings pile TP-2 area was identified during the preliminary assessment work. A small earthen dam is present on the east side of the north-south haul road. During the field work, Olympus extended the boundary of the TP-2 facility to the west of the haul road based on a thin cap of strongly oxidized waste rock and the presence of a tan to light brown silty sand with no gravel or rock immediately beneath the waste rock. The tailings are moderately well vegetated with grasses and sage brush, especially in that portion on the east side of the haul road. Vegetation in the tailings area on the west side of the haul road is sparse.

The TP-2 tailings volume was estimated using the detailed topographic survey of the tailings surface and the test pit data (Figure 3-2). A total of 5 backhoe test pits (based on later evaluation of the data, TP-2-6 test pit was only used in the assessment of the waste rock pile WR4 area) were excavated into the TP-2 tailings (Figure 3-2). The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005). The estimated volume of the TP-2 tailings is 2,260 cubic yards (Table 3-2). The tailings plan area is 0.41 acres and the average tailings depth is 3.4 feet. The maximum tailings thickness was 10.3 feet.

The tailings contained in the TP-2 area are predominantly tan to light brown silty sand. The only tailings slimes, 1.7 feet thick, were intersected in test pit TP-2-1 and these were composed of slightly moist, orange brown clayey silt. In the tailings pile TP-2 area, a thin cap of strongly oxidized waste rock or mixed waste rock and tailings covers that portion of the pile near the former mill area. The native soils beneath the tailings generally consist of light brown sand containing gravel and some rock up to 3-inch diameter. Some oxidized lenses were observed in the native soil in TP2-3 test pit. Particle size analyses performed on the TP-2 tailings composite samples are presented in Table 3-3. These results indicate that the tailings are predominantly sandy silts that contain clay concentrations ranging from 7% to 14%.

Representative samples were collected from backhoe test pits. Samples included vertical channel samples taken from test pit walls and test pit excavation stockpiles. Individual samples were collected based on similar geologic characteristics. Sixteen tailings samples and two representative composite tailings samples were collected from the TP-2 tailings area for XRF screening (Appendix A). In addition, two native soil samples were collected for XRF screening. The TP-2 XRF concentration range results for the principal elements of interest are as follows: As (no detection - 587.6 ppm ), Cr (518 - 2,160 ppm), Cu (no detection - 1,929.6 ppm), Fe (14,796.8 - 86,579.2 ppm), Mn (no detection - 2,209.6 ppm), Mo (no detection - 21.1 ppm), Pb (no detection - 5,718.4 ppm), and Zn (111.5 - 3,638.4 ppm). Mercury was not detected via XRF analysis.

Two native soil samples were collected below the tailings for XRF screening analysis. When compared to background soil and the mean element concentrations for tailings pile TP-2, the results suggest that there is some mobilization of Pb and Zn from the tailings into the native soils.

Laboratory analytical data for the two composite samples collected from the TP-2 area are summarized in Table 3-4. The tailings pH is slightly alkaline at 7.9 standard units (SU). The mean concentrations and the mean concentrations relative to background mean concentrations for analytes with greater than 50 percent of the samples reporting above the method detection limit are as follows:

**TP-2 Tailings Mean Element Concentrations Compared to Background** (quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ND | 8.1 | 180 | 1.5 | 17 | 58.4 | 15,600 | ND | 403 | 15 | 103 | ND | 361 | ND |
| | *0.9x* | *1.2x* | *>3.0x* | *0.5x* | *1.7x* | *1.0x* | | *0.8x* | *0.7x* | *2.8x* | | *4.6x* | |

Notes: *Analytes Cd, Hg and Sb were analyzed but not detected in background samples;*
*½ detection limit used for statistics*
*Total cyanide was not analyzed in background soil*
*ND – not detected above method detection limit*

The mean concentrations from the laboratory quantitative analyses on representative composite samples generally corroborate the XRF screening concentration results with the exception of Cr, Mn, and Ni which were significantly higher in the XRF method. The analytes with an average concentration greater than or equal to three times the average background soil concentration include Cd and Zn.

#### 3.2.1.3 Tailings Pile TP-3 Volume, Geology and Chemistry

Tailings pile TP-3 is located in the NE¼, SE¼ Section 19, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). The TP-3 tailings pile is located immediately downslope from the tailings pile TP-2 dam. The TP-3 tailings impoundment was constructed with a small berm located at the southwest end of the TP-3 area. The tailings are sparsely vegetated. Figure 3-2 presents the topography and location of backhoe test pits used in the assessment of tailings pile TP-3.

The TP-3 tailings volume was estimated using the detailed topographic survey of the tailings surface and the test hole data. Four backhoe test pits were excavated into the TP-3 tailings and a single test pit, TP-3-1, was excavated to investigate a possible overflow area from TP-2 (Figure 3-2). The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005). The estimated volume of the TP-3 tailings is 3,150 cubic yards (Table 3-2). The tailings plan area is 0.36 acre and the average tailings depth is 5.4 feet. The maximum tailings thickness measured in the holes was 11.7 feet.

The TP-3 tailings pile consists of predominantly tan to light brown, silty sands with lesser tailings slimes consisting of bluish gray silty clay to brown clayey silt. The slime zones generally show fine banding and may exhibit orange brown FeOx coloration. All test pits intersected native soil which consisted of light greenish gray, fine to medium-grained sand with gravel and rock generally less than 3-inch diameter. In the tailings pile area, the native soils showed variable yellow to orange brown FeOx in test pits TP-3-4 and TP-3-5. No moisture of any significance was observed in the tailings or native soils below the tailings.

Particle size analyses for selected tailings intervals are summarized in Table 3-3. Representative composite samples of the tan to light brown silty sand, bluish gray/brown silty clay to clayey silt, and tan silty sand were selected for particle size analysis. The analytical results indicate sandy silt with 23% clay, clayey silt, and sandy silt with 13% clay, respectively.

Representative tailings samples were collected from backhoe test pits. Samples included vertical channel samples taken from test pit walls and samples collected from test pit excavation stockpiles. Individual samples were collected based on similar geologic characteristics. Ten tailings samples and three representative composite tailings samples were collected from the TP-3 tailings area for XRF screening (Appendix A). In addition, three native soil samples were collected from below the tailings for XRF screening. The TP-3 XRF concentration range results for the analyzed principal elements of interest are as follows: As (no detection – 270.8 ppm ), Cu (no detection – 552 ppm), Fe (15,692.8 – 53,555.2 ppm), Hg (no detection – 99.1 ppm), Mn (no detection - 2,268.8 ppm), Mo (no detection – 60.6 ppm), Pb (no detection – 4,988.8 ppm), and Zn (71.5 – 1,748.8 ppm).

Three native soil samples were collected below the tailings for XRF screening analysis. When compared to background soil and the mean element concentrations for tailings pile TP-3, the results suggest that there is some mobilization of Mn and Zn from the tailings into the native soils. Although XRF Cr is elevated in the native soils, the accuracy of the XRF method for Cr is questionable. A review of the analytical data for tailings composite samples shows that the quantitative laboratory method results for Cr are significantly lower than the qualitative to semi-quantitative XRF method.

Laboratory analytical data for the three composite samples collected from the TP-3 area are summarized in Table 3-4. The tailings pH is slightly alkaline ranging from 7.5 to 8.0 standard units (SU). The following are the mean concentration and enrichment relative to the background mean concentrations for each element. The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Pb, and Zn.

**TP-3 Tailings Mean Element Concentrations Compared to Background** (quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.6 | 177.4 | 111.2 | 3.5 | 17.5 | 505 | 28,300 | ND | 462 | 20.1 | 1904.8 | ND | 308.3 | ND |
| *>8.6x* | *19.7x* | *0.7x* | *>7.0* | *0.5x* | *14.7x* | *1.9x* | | *0.9x* | *0.9x* | *50.8x* | | *3.9x* | |

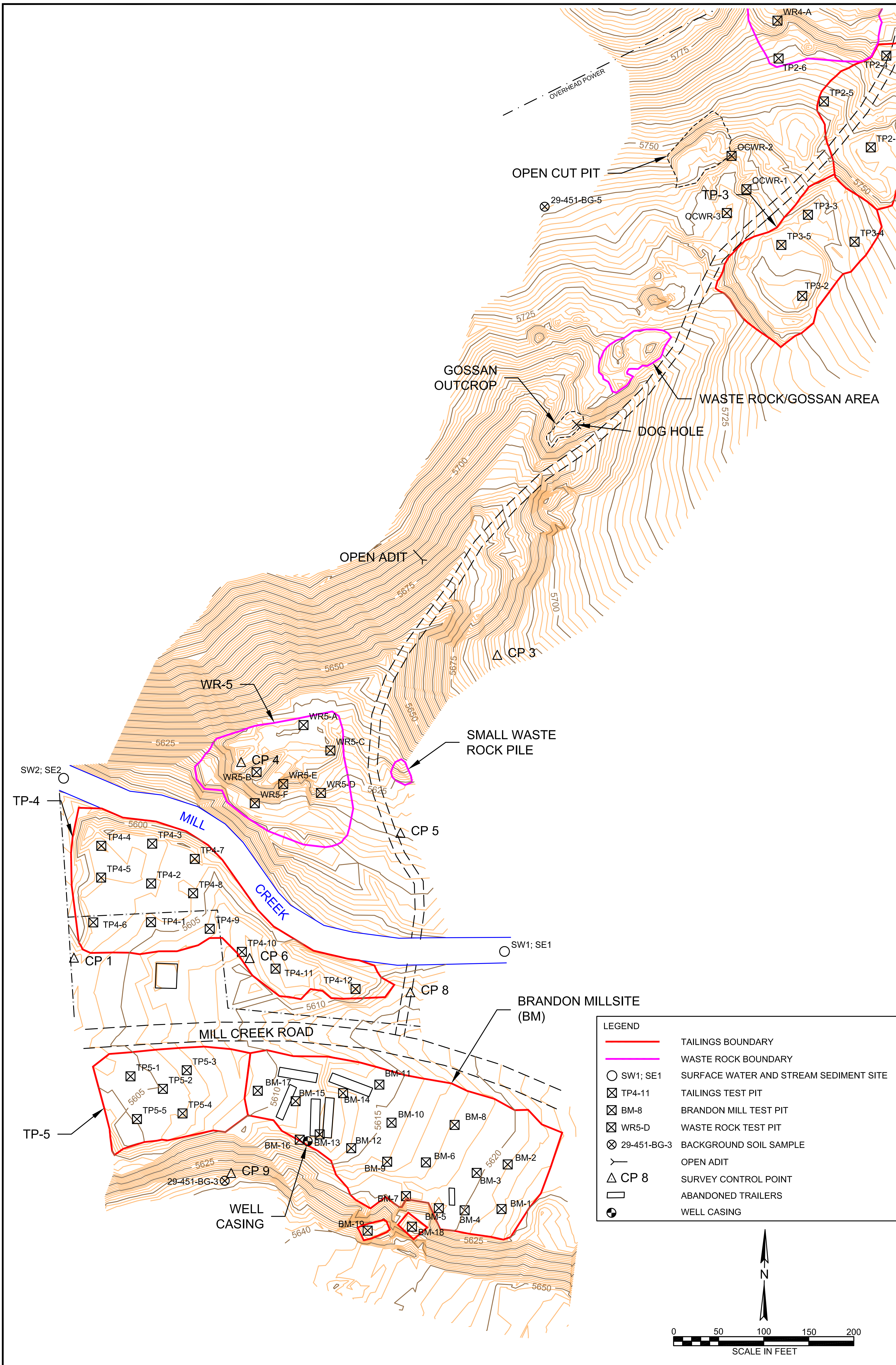
Notes: *Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples; ½ detection limit used for statistics*
*Total cyanide was not analyzed in background soil*
*ND – not detected above method detection limit (Ag detected in only one sample – 59.7 mg/Kg)*

3.2.1.4 Tailings Pile TP-4 Volume, Geology and Chemistry

Tailings pile TP-4 is located in the SE¼, SE¼ Section 19, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). The northern boundary of the tailings pile is juxtaposed against the south side of Mill Creek. A barbed-wire fence encompasses the majority of tailings pile TP-4 with the exception of the southwestern portion. The tailings are sparsely vegetated with large areas of the surface exposed. The surface area is variably oxidized as evidenced by the orange to red to yellow brown FeOx coloration. A thin crust has developed on much of the tailings, but this crust is easily breached as evidenced by deer footprints. White salts are common on the surface in the exposed tailings areas. Minor metal wire debris and a tree limb brush pile are present on the tailings within the fenced area. Some test pits intersected wooden timber materials and some metal debris at depth in the tailings pile. Stormwater/snowmelt runoff has breached the northern tailings berm in the northeastern portion of the tailings pile. The tailings have been eroded into Mill Creek and the small channel area is now cut to native cobbles. The cobbles show various degrees of red to orange brown coloration due to iron oxide coatings. A residence with a well house is located within 100 feet to the southwest of the TP-4 tailings pile (Figure 1-2).

A detailed survey of the TP-4 area was completed and the topographic map is shown on Figure 3-3. The TP-4 tailings volume was estimated using the detailed topographic survey of the TP-4 area and the backhoe test pit and shovel/hand auger hole data. One backhoe test pit and 11 shovel/hand auger holes were excavated into the TP-4 tailings area. The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005). The estimated tailings volume of the TP-4 area is 3,170 cubic yards. Tailings pile TP-4 occupies the largest area of any of the Buckeye tailings impoundments. The tailings plan area is 0.77 acre and the average tailings depth and maximum thickness are 2.6 feet and 9.4 feet, respectively.

The tailings in the TP-4 area are variably-colored silty sand to sand with lesser clayey silt. The non-oxidized silty sand and sand tailings vary in color from tan to light brown to gray. Much of the surface and most holes show various degrees of iron oxidation manifested as orange to yellow brown coloration. The finer-grained tailings are predominantly bluish gray with lesser light tan clayey silts to silty clays. The bluish gray clayey silt slimes intersected in test hole TP4-4 were moderately saturated and the hole was slumping near the bottom. The test hole data indicate that the deepest portion of the TP-4 tailings is in the northwestern portion and this area contains the thicker sections (≤3.6 feet) of slime tailings. White salts are present on much of the exposed tailings surface. Based on the concentration of tracks in the salt areas, deer frequently visit these sites probably to consume the salts.




| Olympus Technical Services, Inc. | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE SITE<br>MADISON COUNTY, MONTANA | LOWER BUCKEYE MINE SITE AND BRANDON MILL AREA | FIGURE 3-3 |
|---|---|---|---|

| DESIGN: | DRAWN: KSR | CHECKED: CRS | APPROVED: | DATE: 4/2005 | JOB NO: A1475 | SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg |
|---|---|---|---|---|---|---|---|

Most of the test holes intersected native soils composed predominantly of dark brown sand with variable concentrations of gravel and lesser rock up to 3-inch diameter. The native soils exposed and intersected in test holes in the southeastern portion of TP-4 tailings exhibit strong oxidation with dark reddish brown to red coloration. In this area, the tailings are thin and tailings have been eroded via stormwater/snowmelt runoff.

Particle size analyses for selected tailings intervals are summarized in Table 3-3. The laboratory analysis for the representative samples of oxidized silty sand, bluish gray clayey silt to silty clay, and non-oxidized silty sand to sand tailings from TP-4 indicates that these tailings are silty sand with 21% clay, clayey silt, and silty sand with 8% clay, respectively.

Representative samples were collected from vertical channel samples taken from shovel pit or backhoe pit walls or from grab samples collected from the excavation stockpiles or hand auger borings. Individual samples were collected based on similar geologic characteristics. Fifteen tailings samples and three representative composite tailings samples were collected from the TP-4 area for XRF screening (Appendix A). In addition, six native soil samples were collected for XRF screening. The TP-4 tailings XRF concentration range results for the analyzed principal elements of interest are as follows: As (no detection – 291.8 ppm ), Cr (546.4 – 3,628.8 ppm), Cu (no detection – 3,308.8 ppm), Fe (11,596.8 – 12,792 ppm), Mn (no detection – 1,229.3 ppm), Mo (no detection – 26.9 ppm), Pb (1,040 – 12,896 ppm), and Zn (172.8 – 20,697.6 ppm). Mercury was detected only in a single sample at 125.3 ppm. One representative sample (TP4-SALT) was collected of the white salts on the tailings surface for XRF analysis. The result indicated elevated concentrations of Cr (2,228.8 mg/Kg), Cu (445.6 mg/Kg), Ni (4,038.4 mg/Kg), Pb (1200 mg/Kg) and Zn (13,299.2 mg/Kg). Quantitative laboratory results for tailings composite samples indicate that the XRF results are much higher for Cr and Ni, thus the XRF accuracy for these elements is questionable.

Five representative native soil samples from beneath the tailings were collected for XRF screening and a single composite sample of a small soil stockpile in the area of the TP-4 tailings was also collected for XRF screening analysis. The results suggest some mobilization of Zn from the tailings into the native soils. Based on the fact that Cd concentrations have been shown to correlate with Zn, it is probable that there is also some mobilization of this element. The Cr and Ni XRF results are also elevated, but as discussed earlier, these results are questionable. Although mercury was also detected in most of the native soil samples, XRF has proven to be an unreliable method for analysis of this element.

Laboratory analytical data for the three composite samples collected from the TP-4 area are summarized in Table 3-4. The tailings pH is acidic to near neutral ranging from 5.9 to 7.4 standard units (SU). The following are the mean concentration and enrichment relative to the background mean concentrations for each element.

**TP-4 Tailings Mean Element Concentrations Compared to Background** (quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32.5 | 223.3 | 43.9 | 50.2 | 9.4 | 1,004 | 28,933.3 | 2.0 | 787.7 | 20.7 | 3,976.7 | 25.0 | 7,550 | ND |
| *>13.0x* | *24.8x* | *0.3x* | *>100.4x* | *0.3x* | *29.2x* | *1.9x* | *>4.1x* | *1.6x* | *0.9x* | *106.0x* | *>10.0x* | *95.8x* | |

*Notes: Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples;*
*½ detection limit used for statistics*
*Total cyanide was not analyzed in background soil*
*ND – not detected above method detection limitl*

The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Hg, Pb, Sb and Zn.

#### 3.2.1.5 Tailings Pile TP-5 Volume, Geology and Chemistry

The tailings pile TP-5 is located in the SE¼, SE¼ Section 19, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). This small tailings area occurs on the south side of Mill Creek road to the south of tailings pile TP-4. The tailings are bounded on the west by a small tailings dam or berm. The size of the trees growing in this berm indicates that the dam is relatively old. The orientation of this dam is such that it is on-line with the TP-4 dam located to the north across Mill Creek road. The tailings are sparsely vegetated with grass and weeds. A residence with a well house is located within 50 feet to the west of the TP-5 tailings dam (Figure 1-2).

A detailed survey of the TP-5 tailings area was completed and the topographic map is shown on Figure 3-3. The TP-5 area tailings volume was estimated using the detailed topographic survey of the TP-5 tailings surface and the shovel/auger hole data. Five shovel/hand auger holes were excavated to evaluate the TP-5 tailings area. The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005). The estimated tailings volume of TP-5 is 900 cubic yards. The tailings plan area is 0.36 acres and the average tailings depth and the maximum thickness are 1.6 and 2.5 feet, respectively.

The TP-5 tailings are predominantly light brown silty sands with lesser light green to beige colored silty clays. The tailings are generally non-oxidized with the exception of occasional light orange brown FeOx. Particle size analyses for selected tailings intervals are summarized in Table 3-3. The laboratory analyses for representative samples of light brown silty sand and oxidized silty sand tailings from TP-5 indicate that both of these tailings are silty sands containing up to 15% clay. The native soils beneath the tailings are chocolate brown silty sands with gravel. The contact between tailings and native soil is generally sharp and FeOx is distinctly absent in the native soil near the contact zone.

Representative samples were collected from vertical channel samples taken from shovel test pit walls. Individual samples were collected based on similar geologic characteristics. Six tailings samples and two representative composite tailings samples were collected from the tailings pile TP-5 area for XRF screening (Appendix A). In addition, two native soil samples were collected for XRF screening. The TP-5 tailings XRF concentration range results for the analyzed principal elements of interest are as follows: As (no detection – 238.4 ppm ), Cr (941.6 – 101,990.4 ppm), Cu (no detection – 430 ppm), Fe (25,190.4 – 283,385.8 ppm), Mo (no detection – 457.2 ppm), Ni (no detection – 40,576 ppm), Pb (213.2 – 2,520 ppm), and Zn (283.2 – 3,000 ppm).

The mean concentrations from the laboratory quantitative analyses on representative composite samples generally corroborate the XRF screening concentration results with the exception of Cr and Ni which were significantly higher in the XRF method and Mn, with the exception of a single sample, was not detected in XRF analysis.

Two representative native soil samples below the tailings were collected for XRF screening. The XRF results indicate that Zn and Pb (in one sample) are elevated greater than 3 times background soil concentrations. The XRF results indicate that both Cr and Ni are also elevated in the native soils beneath the tailings, but these data are suspect as discussed earlier.

Laboratory analytical data for the two composite samples collected from the TP-5 tailings are summarized in Table 3-4. The tailings pH is acidic ranging from 4.7 to 6.1 standard units (SU). The following are the mean concentration and enrichment relative to the background mean concentrations for each element.

**TP-5 Tailings Mean Element Concentrations Compared to Background** (quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17.3 | 164 | 72.9 | 11.0 | 24.6 | 372.5 | 25,900 | 1.5 | 432.5 | 20.5 | 2,170 | 7.1 | 1,960 | ND |
| *>6.9x* | *18.2x* | *0.5x* | *>22.0x* | *0.7x* | *10.8x* | *1.7x* | *>3.0x* | *0.9x* | *0.9x* | *57.9x* | *>2.8x* | *24.9x* | |

*Notes: Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples; ½ detection limit used for statistics*
*Total cyanide was not analyzed in background soil*
*ND – not detected above method detection limitl*

The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Hg, Pb, and Zn.

### 3.2.2 Buckeye Mine Waste Rock Piles Volume, Geology and Chemistry

The Buckeye Mine site waste rock piles are located in SE¼ Section 19 and SW¼ Section 20, Township 4 South and Range 4 West, Montana Principal Meridian (Figures 1-1 and 1-2). Waste rock piles WR-1 through WR-4 (Figure 3-2) are located in the northern portion of the Buckeye Mine site to the east of the former mill site and an ephemeral tributary of Mill Creek. Waste rock pile WR-5 (Figure 3-3) is located on the north side of Mill Creek in the southern portion of site.

The waste rock piles WR-1 through WR-3 are small piles associated with limited underground mine workings. Collapsed adits are evident upslope from WR-1 and WR-2 and to the north of WR-3. Based on the lush grass vegetation pattern, the adit near waste rock pile WR-2 is periodically seeping water. The rock piles are generally devoid of vegetation or are only sparsely vegetated with the exception of waste rock pile WR-3. This pile is moderately well vegetated with grasses and sage brush, especially on the southern-most pile.

Waste rock piles WR-4 and WR-5 are the largest areas of waste rock contained in the Buckeye Mine site project area. Waste rock pile WR-4 includes much of the former mill area and waste rock located along the access road to the mill site. The two small wooden buildings associated with the mill site are located on top of this waste rock pile. A concrete pad approximately 60 feet by 40 feet with a small wooden hopper structure is located immediately to the east of waste rock pile WR-4. This is the site of the former mill building. A wooden headframe with track for an ore car dump station and an ore bin structure occurs just to the north of the northern boundary of waste rock pile WR-4. The ore bin contains some residual ore. Waste rock pile WR-5 is the southern-most pile at the site and is a strongly oxidized pile with nil vegetation. Some minor wood and metal and a small concrete foundation are associated with this pile. Some minor wood and metal debris are present in the area of the other the waste rock piles. Minor 2-inch diameter PVC pipe and plastic sheeting are located near the toe of waste rock pile WR-2.

Topographic surveys were completed on the five waste rock piles (WR-1 through WR-5) in the Buckeye Mine site area (Figures 3-2 and 3-3). The survey data were used to calculate volume estimates for the waste rock piles. The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2005).

Waste rock pile WR-1 is located to the northeast of tailings pile TP-1 area (Figure 3-2) on the east side of an ephemeral drainage. Waste rock pile WR-1 consists of two small piles, the larger is adjacent to the ephermal drainage and the smaller is located up the slope to the east. The estimated volume of WR-1 (west and east piles) is 180 cubic yards. The combined plan area of WR-1 is 0.10 acres and the average and maximum waste rock depths are 1.2 feet and 4.5 feet for the west pile and 1.1 feet and 4.6 feet for the east pile.

Waste rock pile WR-2 is located to the east of tailings pile TP-1 (Figure 3-2). The waste rock pile area is composed of two defined piles of nearly equal volumes. The slightly larger pile is located within the ephemeral drainage where it appears to have been used to build a haul road across the drainage. The infilling of the ephemeral drainage with waste rock has formed a dam across the drainage. A loading dock, constructed of logs and waste rock with dimensions of 19 wide by 37 foot long by 4 feet high, is located in the northeast corner of this waste rock pile. The other portion of waste rock pile WR-2 is located on the east side of the ephemeral drainage and its toe is adjacent to the drainage. A collapsed adit is located to the northeast and upslope from the waste rock pile. The two piles were differentiated based on geology which will be discussed later. The total estimated volume of WR-2 is 1,269 cubic yards. The total plan area of WR-2 is 0.28 acres and the average and maximum waste rock depths are 3.4 feet and 10.6 feet for WR-2 and 2.3 and 7.9 for WR-2 West.

Waste rock pile WR-3 is located to the southeast of WR-2 (Figure 3-2). The waste rock pile area is comprised of two small piles aligned nearly north and south. A collapsed adit is located near the northern-most pile of WR-3. The total estimated volume of WR-3 is 220 cubic yards. The total plan area of WR-3 is 0.08 acres and the average and maximum waste rock depths of the north pile are 1.3 feet and 3.5 feet and 1.7 feet and 3.9 feet for the south pile.

Waste rock pile WR-4 is comprised of two areas, the larger of which is located to the west of the former mill site concrete pad. A second area of oxidized waste rock is associated with the north-south portion of the access road to the former mill site (Figure 3-2). The estimated total volume of WR-4 is 3,730 cubic yards. The total plan area of WR-4 is 0.71 acres and the average and maximum waste rock depth for the main pile are 4.3 feet and 11.4 feet and 1.4 feet and 1.5 feet for the WR-4 road area.

Waste rock pile WR-5 is located just to the north of Mill Creek (Figure 3-3). The waste rock area consists of one main pile. A small pile is located to the east of the main pile and only a visual estimate (±10 cubic yards) of the volume was made. The total estimated volume of WR-5 is 2,280 cubic yards (estimated 2,290 cubic yards with small pile). The plan area of WR-5 is 0.42 acres and the average and maximum waste rock depth are 3.4 feet and 14.5 feet, respectively.

A small waste rock pile composed principally of iron oxide-rich gossan is located to the southwest of tailings pile TP-3. This material appears to have been excavated from a small adit (dog hole) constructed in a silica-rich gossan rock outcrop (Figure 3-2). The total estimated volume is 160 cubic yards. The plan area of the gossan is 0.07 acres and the average and maximum waste rock depth are 1.4 feet and 4.9 feet, respectively.

A small open-cut pit area is located to the northwest of tailings pile TP-3. The pit was excavated along the strike of a silicified shear zone (Figure 3-2). Some small waste rock piles are located between the pit and the north-south haul road. The total volume of these waste rock piles is estimated to be ±50 cubic yards.

The Buckeye Mine waste rock piles are relatively small structures (estimated total less than 8,000 cubic yards) with WR-4 containing the largest individual volume at 3,170 cubic yards. With the exception of a minor volume of waste rock associated with the small open-cut, the piles appear to have been generated from underground mine operations that were generally limited in extent. The predominant rock type contained in the Buckeye Mine waste rock piles is biotite schist and/or biotite gneiss with lesser granodiorite. Milky-white quartz vein material containing nil to moderate concentration of FeOx is conspicuous in most of the waste rock piles. Some occasional primary pyrite was observed associated with quartz veins and zones of intense silicification in the schist/gneiss and granodiorite. With the exception of the western portion of waste rock pile WR-2 and waste rock pile WR-3, the waste rock piles generally show moderate to intense oxidation manifested by intense yellow to orange brown FeOx. Waste rock piles WR-4 and WR-5 are the most intensely oxidized piles and both have noticeable sulfur odor. In the more intensely oxidized rock, primary rock textures are obliterated. Silicification is the dominant hydrothermal alteration present in the Buckeye Mine site area. In the more intense silicified zones, iron oxide-rich gossans are present. A representative outcrop of this material is present to the southwest of tailings pile TP-3 on the west side of the north-south haul road.

Representative samples were collected from shovel and/or backhoe pits excavated into the waste rock piles. Individual samples were collected based on similar geologic characteristics. Twenty-seven waste rock samples and six representative composite samples were collected from waste rock piles WR-1, WR-2, WR-3, WR-4, WR-5 and the open-cut area waste rock piles (OCWR) for XRF screening (Appendix A). The Buckeye Mine waste rock XRF concentration range results for the principal elements of interest are as follows: As (no detection – 541.6 ppm), Cr (no detection – 5,078.4 ppm), Cu (no detection – 823.2 ppm), Fe (16,588.8 – 102,963.2 ppm), Hg (no detection – 540.8 ppm), Mn (no detection – 3,619.2 ppm), Ni (no detection – 35,891.2 ppm), Mo (no detection – 29 ppm), Pb (no detection – 12,294.4 ppm), and Zn (no detection – 16,691.2 ppm). These XRF concentration ranges do not include the WR4-ORE sample results for these data were collected from a rock sample and are not representative of the finer-grained fraction of the waste rock piles.

Laboratory analytical data for the six composite samples collected from the Buckeye Mine waste rock piles are summarized in Table 3-5. Where applicable, the mean concentrations from the laboratory quantitative analyses on representative composite samples generally corroborate the XRF screening concentration results with the exception of Cr, Ni and Hg which when detected in XRF were significantly higher. With the exception of waste rock pile WR-3 (pH = 7.8 S.U.), all of the waste rock piles are acidic with pH ranging from 2.8 to 6.5 S.U. Waste rock piles WR-4 and WR-5 are the most acidic. The following are the mean concentration and enrichment relative to the background mean concentrations for each element.

**Table 3-5. Laboratory Chemistry Results for Waste Rock**

| Sample ID | pH (SU) | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Waste Rock Piles WR1, WR2 and WR3** | | | | | | | | | | | | | | |
| 29-451-WR-1 | 6.5 | 9.2 | 328 | 84.3 | 17.9 | 57.9 | 208 | 50100 | <1 | 1130 | 75.3 | 1380 | <5 | 4080 |
| 29-451-WR-2 | 7.8 | <5 | 28.4 | 192 | 2.9 | 57.9 | 135 | 40400 | <1 | 1120 | 48.9 | 267 | <5 | 470 |
| Maximum | 7.8 | 9.2 | 328 | 192 | 17.9 | 57.9 | 208 | 50100 | <1 | 1130 | 75.3 | 1380 | <5 | 4080 |
| Minimum | 6.5 | <5 | 28.4 | 84.3 | 2.9 | 57.9 | 135 | 40400 | <1 | 1120 | 48.9 | 267 | <5 | 470 |
| Mean | 7.15 | 5.85 | 178.2 | 138.2 | 10.4 | 57.9 | 171.5 | 45250.0 | | 1125.0 | 62.1 | 823.5 | | 2275.0 |
| No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Waste Rock WR4** | | | | | | | | | | | | | | |
| 29-451-WR4-1 | 3.4 | 17.6 | 130 | 57.9 | 7.2 | <5 | 281 | 38300 | 2.7 | 108 | <5 | 1920 | <5 | 1270 |
| 29-451-WR4-2 | 5.7 | 77.2 | 318 | 23.6 | 8.4 | <5 | 416 | 35700 | 1.9 | 359 | 7.1 | 18100 | 157 | 1330 |
| Maximum | 5.7 | 77.2 | 318.0 | 57.9 | 8.4 | <5 | 416 | 38300 | 2.7 | 359 | 7.1 | 18100 | 157 | 1330 |
| Minimum | 3.4 | 17.6 | 130.0 | 23.6 | 7.2 | <5 | 281 | 35700 | 1.9 | 108 | <5 | 1920 | <5 | 1270 |
| Mean | 4.6 | 47.4 | 224.0 | 40.8 | 7.8 | | 348.5 | 37000.0 | 2.3 | 233.5 | 4.8 | 10010.0 | 79.8 | 1300.0 |
| No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Waste Rock WR5** | | | | | | | | | | | | | | |
| 29-451-WR5-1 | 4.8 | 119 | 257 | 21.7 | 21.0 | 6.9 | 1110 | 51200 | 2.8 | 299 | 11.3 | 9650 | 56.9 | 3750 |
| 29-451-WR5-2 | 2.8 | 52.6 | 188 | 25.5 | 3.3 | <5 | 939 | 45700 | 5.0 | 58.8 | <5 | 11100 | 11.4 | 716 |
| Maximum | 4.8 | 119 | 257 | 25.5 | 21 | 6.9 | 1110 | 51200 | 5 | 299 | 11.3 | 11100 | 56.9 | 3750 |
| Minimum | 2.8 | 52.6 | 188 | 21.7 | 3.3 | <5 | 939 | 45700 | 2.8 | 58.8 | <5 | 9650 | 11.4 | 716 |
| Mean | 3.8 | 85.8 | 222.5 | 23.6 | 12.15 | 4.7 | 1024.5 | 48450 | 3.9 | 178.9 | 6.9 | 10375 | 34.15 | 2233 |
| No. of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**LEGEND**

29-451-WR-1 is a composite of WR2-B; WR1-A; WR2-C; WR1-C
29-451-WR-2 is a composite of WR3-A; WR3-B; WR3-C
29-451-WR4-1 is a composite of WR4-B-0-3.7; WR4-D-0-3.2; WR4-E-0-1.3
29-451-WR4-2 is a composite of WR4-B-3.7-5.7; WR4-C-4.3-5.9
29-451-WR5-1 is a composite of WR5-A-0-1.8; WR5-C-0-2.0; WR5-E-0-2.0
29-451-WR5-2 is a composite of WR5-D-0-2.0; WR5-A-0-2.0

Note: Statistics - one half the lower detection limit is used where below detection limit samples are included in the mean calculation

**Buckeye Mine Waste Rock Mean Element Concentrations Compared to Background**
(quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46.4 | 208.2 | 67.5 | 10.1 | 21.7 | 514.8 | 43,566.7 | 2.23 | 512.5 | 24.6 | 7,069.5 | 38.8 | 1,936 | a |
| *>18.5x* | *23.1x* | *0.4x* | *>20.2x* | *0.7x* | *15.0x* | *2.9x* | *>4.5x* | *1.0x* | *1.1x* | *188.5x* | *>15.5x* | *24.6x* | |

*Notes: Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples; ½ detection limit used for statistics*
*a - Analyte total cyanide was not analyzed in waste rock samples*

The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Hg, Pb, Sb and Zn. With the exception of waste rock pile WR-3, the Buckeye Mine waste rock contains significantly elevated concentrations of a diverse suite of metal/metalloid elements.

### 3.2.3 Brandon Mill Waste Area Volume, Geology and Chemistry

Another former millsite located in the Buckeye Mine project area is the Brandon Mill. This site is also referred to as the Buckeye Mill in the site cultural resources assessment report, (Frontier Historical Consultants, 2003). The former Brandon mill is located south of Mill Creek road (Figure 3-3). A rock foundation wall, 30 feet long by 8 feet high, on the hillside marks the former mill building site. Abundant debris is associated with this site, much of it related to more modern operations. An inventory of the debris in the Brandon millsite area is presented in Table 3-6.

The former millsite surface area is composed predominantly of native soils consisting of sand and gravel with cobbles. There are some obvious pockets of mine tailings and crushed ore principally in the former mill building area. The tailings are most likely spillage and residual tailings washed out of the mill building during operations. Based on oxidation evidence and XRF screening analysis, much of the near surface (≤2 feet) native soils in the former mill area have been impacted by former operations. Two likely sources of contaminants impacting the near surface native soils are tailings spills and particulate emissions from crushing operations.

The survey data were used along with nineteen shovel pits to calculate a volume estimate for the impacted soils and wastes (includes tailings and crushed ore) identified in the Brandon millsite area. The volume estimate methods are detailed in the Buckeye Mine site characterization report (DEQ-MWCB/Olympus, 2004). The estimated volume of the impacted soils and identified mill wastes is 2,750 cubic yards. Shovel pits and XRF screening analysis indicated a maximum 2 feet depth for the impacted soils in this area. The volume estimate makes provision for the extraction of the upper 2 feet of soils in the millsite area. The plan area is 0.98 acres and the average and maximum impacted soil depths are 1.7 feet and 2.0 feet, respectively.

The native soils located in the Brandon Mill area are typically chocolate brown, silty sand with variable gravel and cobbles. It is difficult to differentiate impacted native soils from non-impacted soils. The XRF screening provides the most reliable method for defining the impacted soils. When present, the field characteristics that support impacted native soils include pockets of light tan, silty sand tailings or variable yellow to orange brown iron oxidation.

**TABLE 3-6. INVENTORY OF DEBRIS ASSOCIATED WITH THE BRANDON MILLSITE**

| Item Description | Quantity | Comment(s) |
|---|---|---|
| Lead-Acid Batteries | 16 | Automotive batteries |
| Vehicle Tires, various sizes | 21 | |
| 55-gallon Steel Drums | 16 | 2 drums - estimate. ¼ full of liquid |
| 40-gallon Steel Drums | 4 | Empty |
| 2.5 gallon Steel Pail | 1 | Used oil + solids, no cover |
| Fuel Storage Tank (6 ft. long by 3 feet diameter) | 1 | Empty |
| Fuel Oil Tank (5.5 feet long by 3.5 feet high) | 1 | Empty |
| Propane Bottle – 30 gallon? | 1 | |
| Steel Cable Reel (¾ inch diameter) and one smaller steel cable reel | 2 | |
| Large Conveyor Belt Motor – 5.5 inch diameter shaft | 1 | |
| Dilapidated House Trailers (approximately 50 feet long by 10 feet wide) | 5 | Abundant household goods, clothes, paper, etc. and mice/rat feces |
| Dilapidated Travel Trailer (approximately 20 feet long by 5 feet wide) | 1 | |
| Wooden Rack Trailer | 1 | Full of junk including kitchen stove |
| Large, steel, ~8 feet diameter unknown devices with screens; likely mill processing equipment | 4 | |
| Other Miscellaneous Wood/Metal Debris | Estimate ±3 10 cubic yard truck loads | |

Tailings occur in larger pockets, especially in the immediate area of the old mill site. This material is typically light tan, silty sand with variable FeOx. Occasional greenish gray, clayey silt tailings slime is present as a thin layer in the silty sands. Two small areas of crushed and coarse ground ore are located on the old mill foundation bench on the side of the hill. This material consists of both primary and oxidized ore. Cubic pyrite is a significant sulfide mineral component in the non-oxidized, greenish gray coarse sand ore. The strongly oxidized ore is typically a yellow FeOx-rich rock with a strong sulfur odor.

Representative samples were collected from shovel pits excavated into the waste rock piles. Individual samples were collected based on similar geologic characteristics. Twenty-three soil and waste rock samples and three representative composite samples were collected from the Brandon Mill area for XRF screening (Appendix A). The Brandon Mill soil and waste rock XRF concentration range results for the principal elements of interest are as follows: As (no detection – 1,480 ppm ), Cu (no detection – 1,029.6 ppm), Cr (726 – 8,307.2 ppm), Fe (31,692.8 – 180,940.8 ppm), Hg (no detection – 1,109.6 ppm), Mn (no detection – 7,104 ppm), Mo (no detection – 35 ppm), Ni (no detection – 55,552 ppm), Pb (79.6 – 38,195.2 ppm), and Zn (306.6 – 8,588.8 ppm). In the XRF results, Pb and Zn are the most useful elements for determining impacted native soils. The XRF and laboratory results for these elements generally show strong correlation with correlation coefficients of 0.93 and 0.98, respectively.

Laboratory analytical data for the three representative composite samples collected from the Brandon Mill area are summarized in Table 3-4. For the elements that have both XRF and laboratory results, the mean concentrations from the laboratory quantitative analyses on representative composite samples generally corroborate the XRF screening concentration results with the exception of Cr, Hg, Mn, and Ni which are significantly higher concentrations in the XRF method. The impacted soils and waste rock pH are strongly to moderately acidic ranging from 2.1 to 6.5 S.U. The following are the mean concentration and enrichment relative to the background mean concentrations for each element.

**Brandon Mill Waste Area Mean Element Concentrations Compared to Background**
(quantitative laboratory results)

All Results in mg/kg

| Ag | As | Ba | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | T CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 108.5 | 353.3 | 99.3 | 10.6 | 21.4 | 742.5 | 51,900 | 1.5 | 168.7 | 16.1 | 18,435 | 18.1 | 2,045 | a |
| *>43.4x* | *39.3x* | *0.7x* | *>21.2x* | *0.7x* | *21.6x* | *3.4x* | *>3.0x* | *0.3x* | *0.7x* | *491.6x* | *>7.2x* | *26.0x* | |

*Notes: Analytes Ag, Cd, Hg and Sb were analyzed but not detected in background samples;*
*½ detection limit used for statistics*
*a - Analyte total cyanide was not analyzed in waste rock samples*

The analytes with an average concentration greater than or equal to three times the average background soil concentration include: Ag, As, Cd, Cu, Fe, Hg, Pb, Sb and Zn. The near surface soils in the Brandon Mill area are impacted by a diverse suite of metal/metalloid elements typical of polymetallic base metal mineralization.

### 3.2.4 Mill Tailings, Waste Rock and Brandon Mill Wastes Acid-Base Accounting Results

The mill tailings in the Buckeye Mine project area generally show some oxidation especially in the upper zones of the tailings. This is evidenced by orange to yellow to red brown FeOx in the tailings. The tailings piles, TP-1, TP-2 and TP-3, located in the northern portion of the Buckeye

Mine site are generally slightly alkaline in pH. The two tailings piles, TP-4 and TP-5, located in the southern portion of the site are more acidic with pH as low as 4.7 S.U. Tailings pile TP-4 is the most intensely oxidized tailings and contains moderately abundant white salts on the surface.

The modified Sobek method was used to evaluate the acid generating potential of the mill tailings present in the Buckeye Mine site area. A total of thirteen composite samples and one duplicate composite sample were collected for ABA analyses at Energy Laboratories, Inc. The acid-base accounting laboratory analytical results are summarized in Table 3-7. The ABA data indicate that the total sulfur concentrations in the mill tailings are variable ranging from 0.03% to 5.0%. All of the composite samples collected from tailings piles TP-1, TP-2 and TP-3 show positive net neutralization potential (NNP) ranging from +21 to +167 tons per 1000 tons $CaCO_3$ (t/1000t $CaCO_3$). The acid-base accounting results for TP-1, TP-2 and TP-3 suggest that the potential for acid rock drainage is limited.

Tailings piles TP-4 and TP-5 ABA data results show NNP ranging from +32 to -108 t/1000t $CaCO_3$. The results indicate that these tailings have the potential to produce acid rock drainage. The field characteristics and current pH data, especially in tailings pile TP-4, support the ABA results. These tailings are currently acidic, show moderately strong oxidation and are developing white salt deposits on the exposed tailings. The production of acid rock drainage is further corroborated in the southeastern portion of TP-4 where strong reddish brown FeOx staining is evident on stream cobbles. In this area, stormwater/snowmelt runoff has eroded the tailings down to the native surface composed predominantly of stream gravel and cobbles. This area was likely a former tributary stream channel to Mill Creek. The TP-4 and TP-5 tailings also contain higher overall total sulfur concentrations (1.0% to 5.0%) in comparison to the other tailings in the Buckeye Mine site area.

The Buckeye Mine waste rock paste pH data indicate that most of the waste rock is acidic with the exception of WR-3 which is slightly alkaline (7.8 S.U.). Waste rock piles WR-4 and WR-5 exhibit the most intense oxidation. Six representative composite waste rock samples were analyzed by the modified Sobek method for acid-base accounting (ABA) at Energy Laboratories, Inc. The laboratory analytical results are summarized in Table 3-6. The ABA data indicate that the total sulfur concentrations in the waste rock range from 0.02% to 3.5%. The Buckeye Mine site waste rock ABA results are variable depending on the waste rock pile. The composite samples collected from waste rock piles WR-1, WR-2 and WR-3 show positive net neutralization ranging from +30 tons per 1,000 tons (t/1000t) $CaCO_3$ to +46 t/1000t $CaCO_3$. The ABA results from waste rock piles WR-4 and WR-5 show negative net neutralization ranging from -23 t/1000t $CaCO_3$ to -40 t/1000t $CaCO_3$. The data indicate that waste rock piles WR-4 and WR-5 have the greatest potential for acid generation and the field evidence supports this assessment. These piles are the most intensely oxidized with very abundant yellow to orange brown FeOx, have the most acidic pH conditions and exhibit sulfur odor characteristic of oxidizing sulfides.

The Brandon Mill impacted soils and waste rock paste pH data indicate that most of the material is moderately to strongly acidic. The waste materials consist of impacted soils with lesser tailings and partially processed ore. The presence of acid pH conditions indicates that oxidation is causing some acid generation in the wastes.

Three representative composite waste rock samples and a duplicate sample were analyzed by the modified Sobek method for acid-base accounting (ABA) at Energy Laboratories, Inc. and the

**Table 3-7. Acid-Base Accounting Results For Mill Tailings, Waste Rock and Brandon Mill Wastes**

| Sample ID | Total Sulfur (%) | Pyritic Sulfur (%) $HNO_3$ Ext. S | Sulfate Sulfur (%) HCL Ext. S | Residual Sulfur (%) | Acid Gen Potential * | Neutraliz Potential * | Acid/Base Potential * |
|---|---|---|---|---|---|---|---|
| **Buckeye Mine Tailings** | | | | | | | |
| 29-451-TP1-1 | 1.1 | 0.74 | 0.17 | 0.22 | 23 | 44 | 21 |
| 29-451-TP1-2 | 1.5 | 1.4 | 0.07 | 0.09 | 42 | 72 | 30 |
| 29-451-TP1-3 | 0.22 | 0.02 | 0.20 | <0.01 | <1.0 | 117 | 116 |
| 29-451-TP2-1 | 0.04 | 0.02 | 0.02 | <0.01 | <1.0 | 130 | 129 |
| 29-451-TP2-2 | 0.03 | <0.01 | 0.02 | <0.01 | <1.0 | 128 | 128 |
| 29-451-TP3-1 | 0.03 | <0.01 | 0.02 | <0.01 | <1.0 | 167 | 167 |
| 29-451-TP3-2 | 0.62 | 0.55 | 0.04 | 0.03 | 17 | 52 | 35 |
| 29-451-TP3-3 | 0.19 | <0.01 | 0.18 | <0.01 | <1.0 | 106 | 106 |
| 29-451-TP4-1 | 1.0 | 0.73 | 0.21 | 0.05 | 23 | 27 | 3.9 |
| 29-451-TP4-2 | 5.0 | 4.2 | 0.24 | 0.56 | 132 | 24 | -108 |
| 29-451-TP4-3 | 2.0 | 1.6 | 0.22 | 0.21 | 49 | 82 | 32 |
| 29-451-TP5-1 | 0.66 | 0.21 | 0.38 | 0.07 | 6.5 | 5.0 | -1 |
| 29-451-TP5-2 | 1.1 | 0.52 | 0.54 | 0.08 | 16 | 14 | -2 |
| 29-451-TP6-1 | 2.1 | 0.84 | 0.88 | 0.39 | 26 | 51 | 25 |
| **Buckeye Mine Waste Rock** | | | | | | | |
| 29-451-WR-1 | 1.9 | 0.59 | 0.65 | 0.65 | 18 | 48 | 30 |
| 29-451-WR-2 | 0.02 | 0.01 | <0.01 | <0.01 | <1.0 | 46 | 46 |
| 29-451-WR4-1 | 3.1 | 1.4 | 1.4 | 0.33 | 43 | 1.3 | -40 |
| 29-451-WR4-2 | 2.5 | 1.6 | 0.43 | 0.55 | 49 | 26 | -23 |
| 29-451-WR5-1 | 3.5 | 1.3 | 1.6 | 0.60 | 41 | 10 | -30 |
| 29-451-WR5-2 | 3.4 | 1.3 | 1.8 | 0.30 | 41 | <1.0 | -40 |
| **Brandon Mill Wastes** | | | | | | | |
| 29-451-BM-1 | 2.4 | 1.0 | 0.93 | 0.43 | 32 | 5.9 | -26.1 |
| 29-451-BM-2 | 1.7 | 0.62 | 0.71 | 0.36 | 19 | <1.0 | -20 |
| 29-451-BM-3 | 7.6 | 4.5 | 1.5 | 1.6 | 142 | <1.0 | -142 |
| 29-451-BM-4 | 2.1 | 1.3 | 0.66 | 0.10 | 42 | 41 | -0.5 |

* Tons of $CaCO_3$ equivalent per 1000 tons of material

**LEGEND**

See Table 3-4 and Table 3-5 for sample descriptions results are summarized in Table 3-7. The ABA data indicate that the total sulfur concentrations are elevated with concentrations ranging from 1.7% to 7.6%. The composite samples show negative net neutralization ranging from -142 t/1000t $CaCO_3$ to -0.5 t/1000t $CaCO_3$. The ABA results support the fact that the waste materials in the Brandon Mill area are acid generating.

### 3.2.5 Mill Tailings, Waste Rock and Brandon Mill Waste TCLP Results

Because mill tailings and mine waste rock are derived from the beneficiation and extraction of ores, according to the Bevill Amendment they are exempt from federal hazardous waste regulations under the Resource Conservation and Recovery Act (RCRA). However, to evaluate the RCRA metals (Ag, As, Ba, Cd, Cr, Hg, Pb and Se) leaching potential of these wastes, selected samples of the Buckeye Mine waste sources were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP).

Based on the laboratory analytical results for the mill tailings, splits of composite samples were selected for metals (TCLP) analysis. For the eight RCRA metals, chemistry results for mill tailings show that cadmium, lead and mercury are the elements of most concern in the mill tailings contained in the Buckeye Mine site. Based on the laboratory analytical results, four composite mill tailings samples (29-451-TP1-1, 29-451-TP3-2, 29-451-TP4-2 and 29-451-TP5-2) elevated in one or more of these elements were selected for TCLP analysis at Energy Laboratories, Inc.

The Buckeye Mine tailings TCLP laboratory analytical results are summarized in Table 3-8. The results indicate that lead exceeded the regulatory levels for metal toxicity under the RCRA rules for hazardous waste classification in the TP-3 and TP-4 tailings piles. Cadmium was detected in all of the leachates, but at concentrations within the regulatory limit. The highest cadmium leachate concentration (0.8 mg/L) was detected in tailings pile TP-4. Arsenic, barium, chromium, mercury, selenium and silver were not detected in any of the tailings composite sample leachates above the lower detection limit of 0.02 mg/L. The TCLP data suggest that Pb and Cd have the potential to leach from the TP-3 and TP-4 tailings.

Splits of the Buckeye Mine waste rock composite samples 29-451-WR-1, 29-451-WR4-2, and 29-451-WR5-1 were also collected for metals TCLP analysis at Energy Laboratories, Inc.. The waste rock TCLP laboratory analytical results are summarized in Table 3-8. The results indicate that lead concentrations of 80.5 mg/L and 8.3 mg/L in waste rock piles WR-4 and WR-5, respectively, exceeded the regulatory level of 5 mg/L for metal toxicity under the Resource Conservation and Recovery Act (RCRA) rules for hazardous waste classification. Lead was also detected in the leachate from the WR-1 and WR-2 composite sample, but the concentration of 1.1 mg/L is within the regulatory limit. Cadmium was detected in all of the leachates, but the concentrations were within the regulatory limit of 1 mg/L. Arsenic, barium, chromium, mercury, selenium and silver were not detected in TCLP analyses above the method detection limit.

One representative composite sample from the Brandon Mill area of obvious oxidized tailings was collected for metals TCLP analysis at Energy Laboratories, Inc. The TCLP laboratory analytical results are summarized in Table 3-8. The results indicate that the lead concentration (12.1 mg/L) in the oxidized tailings in the Brandon Mill area exceeded the regulatory level of 5 mg/L for metal toxicity under the RCRA rules for hazardous waste classification. Cadmium was the only other analyte detected in the leachate but the concentration (0.3 mg/L) was within the regulatory limit of 1 mg/L.

**Table 3-8. TCLP Metals for Mill Tailings, Waste Rock and Brandon Mill Wastes**

| Sample ID | Ag (mg/L) | As (mg/L) | Ba (mg/L) | Cd (mg/L) | Cr (mg/L) | Hg (mg/L) | Pb (mg/L) | Se (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **Tailings** | | | | | | | | |
| 29-451-TP1-1 | <0.5 | <0.5 | <10 | 0.3 | <0.5 | <0.02 | 1.4 | <0.1 |
| 29-451-TP3-2 | <0.5 | <0.5 | <10 | 0.1 | <0.5 | <0.02 | **11.7** | <0.1 |
| 29-451-TP4-2 | <0.5 | <0.5 | <10 | 0.8 | <0.5 | <0.02 | **73.6** | <0.1 |
| 29-451-TP5-2 | <0.5 | <0.5 | <10 | 0.3 | <0.5 | <0.02 | 2.4 | <0.1 |
| **Waste Rock** | | | | | | | | |
| 29-451-WR-1 | <0.5 | <0.5 | <10 | 0.5 | <0.5 | <0.02 | 1.1 | <0.1 |
| 29-451-WR4-2 | <0.5 | <0.5 | <10 | 0.2 | <0.5 | <0.02 | **80.5** | <0.1 |
| 29-451-WR5-1 | <0.5 | <0.5 | <10 | 0.9 | <0.5 | <0.02 | **8.3** | <0.1 |
| **Brandon Mill Waste** | | | | | | | | |
| 29-451-BM-1 | <0.5 | <0.5 | <10 | 0.3 | <0.5 | <0.02 | **12.1** | <0.1 |
| Regulatory Level | 5 | 5 | 100 | 1 | 5 | 0.2 | 5 | 1 |

**LEGEND**

29-451-TP1-1 is a composite of TP1-1-0-2.8, TP1-3-0-1.6 and TP1-2-0-1.7
29-451-TP3-2 is a composite of TP3-2-0-1.8 and TP3-2-1.8-4.9
29-451-TP4-2 is a composite of TP4-2-2.0-2.6, TP4-4-3.7-5.0 and TP4-11-2.5-3.1
29-451-TP5-2 is a composite of TP5-5-0-2.5 and BM15-0-1.2
29-451-WR-1 is a composite of WR2-B, WR1-A, WR2-C, and WR1-C
29-451-WR4-2 is a composite of WR4-B-3.7-5.7 and WR4-C-4.3-5.9
29-451-WR5-1 is a composite of WR5-A-0-1.8, WR5-C-0-2.0 and WR5-E-0-2.0
29-451-BM-1 is a composite of BM1-0-0.5, BM4-0-1.0 and BM5-0-0.7

## 3.3 SURFACE WATER AND GROUND WATER CHARACTERIZATION

The Buckeye Mine site is located in the Mill Creek drainage, a tributary to the Ruby River. The site is located approximately 11.3 miles above the confluence of Mill Creek and the Ruby River. Tailings TP-4 and waste rock WR-5 piles are adjacent to the banks of Mill Creek. The Brandon Mill and tailings pile TP-5 are located on the south side of Mill Creek road. Tailings piles TP-1 through TP-3 and waste rock piles WR-1 through WR-4 are located above the Mill Creek floodplain near an unnamed, ephemeral tributary. Figures 1-1 and 1-2 show the Buckeye Mine site and its relationship to the Mill Creek drainage.

Two surface water samples were collected to assess potential impacts from the mine/mill waste sources contained in the Buckeye Mine site. Surface water samples, 29-451-SW1 and 29-451-SW2, were collected from Mill Creek to assess potential surface water impact from the Buckeye mine/mill waste sources (Figure 3-3). The background sample, SW1, was collected approximately 100 feet upstream from where the former bridge crossed Mill Creek to allow road access from the mine to the mill area. The sample is upstream of the waste sources associated with the Buckeye Mine site. Sample site SW2 is located downstream of the Buckeye Mine waste sources and is approximately 20 feet downstream of tailings pile TP-4.

Surface water sample 29-451-SW3 was collected from a spring located approximately 30 to 40 feet to the west of the gravel road approximately 0.2 miles north of the gate into the northern portion of the Buckeye Mine site (Figure 1-1).

The surface water samples were collected on July 29, 2004 according to standard protocols as described in the Field Sampling Plan for the Buckeye Mine (DEQ-MWCB/Olympus, 2004a). At each sample site, stream flow was estimated and field parameters including pH and specific conductivity were measured. Surface water samples were analyzed at Energy Laboratories, Inc. for pH, total dissolved solids, sulfate, chloride, nitrate + nitrite as N, hardness and a fifteen element suite including Ag, As, Ba, Ca, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Sb and Zn.

The samples were analyzed by Energy Laboratories, Inc. and the results are summarized in Table 3-9. The surface water chemistry results should represent low flow conditions as they were collected after the snowmelt runoff and not during a stormwater runoff event. The surface water results indicate that Ag, As, Ba, Cd, Cr, Hg, Ni, Pb, Sb and Zn were not detected in any of the surface water samples collected from Mill Creek. For low flow conditions, the data indicate that there is very little impact to the surface water quality and no exceedance of Federal or Montana surface water quality standards in Mill Creek near the site. However, field observations indicate that during snowmelt and/or stormwater runoff events, tailings and waste rock sediment are being eroded into Mill Creek from TP-4 and WR-5, respectively. The analytical results from the discharging spring were similar to the metal/metalloid results from Mill Creek with the exception of the detection of a low concentration of Mn (40 mg/L) and the elevated concentration of total dissolved solids (489 mg/L). The water chemistry results for the spring did not exceed Federal or Montana surface water quality standards.

Except for a well casing that was discovered in the Brandon Mill area during site characterization fieldwork, no groundwater wells occur in the immediate Buckeye Mine site. Two private wells are located just outside the project area boundary near tailings piles TP-4 and TP-5. The aerial orthophotograph presented in Figure 3-4 shows the location of the residences and the general area of the mine/mill wastes identified at the Buckeye Mine site.

**TABLE 3-9. Chemistry Results For Surface Water, Groundwater and Spring Discharge**

**Total Recoverable Metals**

| Sample ID | Ag (ug/L) | As (ug/L) | Ba (ug/L) | Ca (mg/L) | Cd (ug/L) | Cr (ug/L) | Cu (ug/L) | Fe (ug/L) | Hg (ug/L) |
|---|---|---|---|---|---|---|---|---|---|
| 29-451-SW1 | <5 | <3 | <100 | 21 | <1 | <10 | <10 | 70 | <0.6 |
| 29-451-SW2 | <5 | <3 | <100 | 20 | <1 | <10 | <10 | 80 | <0.6 |
| 29-451-SW3 | <5 | <3 | <100 | 89 | <1 | <10 | <10 | 40 | <0.6 |
| 29-451-GW1 | <5 | <3 | <100 | 46 | 7 | <10 | 20 | 200 | <0.6 |
| 25-179-GW2 | <5 | <3 | <100 | 60 | <1 | <10 | <10 | <30 | <0.6 |
| **Federal MCL** | 100 | 50 | 2000 | - | 5 | - | 1000 | 300 | 2 |
| **Montana HHS - SW** | 100 | 18 | 2000 | - | 5 | - | 1300 | 300 | 0.05 |
| **Montana HHS - GW*** * | 100 | 20 | 2000 | - | 5 | - | 1300 | 300 | 2 |
| **Chronic ALS*** | - | 150 | - | - | 0.27 | - | 9.33 | 1000 | 0.91 |
| **Acute ALS*** | 4.06 | 340 | - | - | 2.13 | - | 13.99 | - | 1.7 |

| Sample ID | Mg (mg/L) | Mn (ug/L) | Ni (ug/L) | Pb (ug/L) | Sb (ug/L) | Zn (ug/L) | Total CN (ug/L) |
|---|---|---|---|---|---|---|---|
| 29-451-SW1 | 5.5 | <10 | <10 | <2 | <5 | <10 | NA |
| 29-451-SW2 | 4.9 | <10 | <10 | <2 | <5 | <10 | NA |
| 29-451-SW3 | 35 | 40 | <10 | <2 | <5 | <10 | NA |
| 29-451-GW1 | 16 | 30 | <10 | <2 | <5 | 1310 | <5 |
| 25-179-GW2 | 21 | <10 | <10 | <2 | <5 | 90 | <5 |
| **Federal MCL** | - | 50 | 100 | 15 | 6 | 5000 | 200 |
| **Montana HHS - SW** | - | 50 | 100 | 15 | 6 | 2000 | 200 |
| **Montana HHS - GW**** | - | 50 | 100 | 15 | 6 | 2000 | 200 |
| **Chronic ALS*** | - | - | 52.2 | 3.2 | - | 119.8 | 5.2 |
| **Acute ALS*** | - | - | 469.2 | 81.6 | - | 119.8 | 22 |

**Surface Water Wet Chemistry Results**

| Sample ID | pH (SU) | TDS (mg/L) | Sulfate (mg/L) | Chloride (mg/L) | Nitrate + Nitrite as N (mg/L) | Hardness as $CaCO_3$ (mg/L) |
|---|---|---|---|---|---|---|
| 29-451-SW1 | 7.9 | 85 | 5.4 | 1.8 | <0.05 | 74 |
| 29-451-SW2 | 7.9 | 83 | 6.8 | 1.7 | <0.05 | 69 |
| 29-451-SW3 | 8.0 | 489 | 180 | 6.7 | <0.05 | 364 |
| 29-451-GW1 | 7.3 | 246 | 70 | 5.0 | 0.37 | 183 |
| 25-179-GW2 | 7.5 | 316 | 140 | 6.0 | 0.71 | 235 |
| **Federal MCL** | 6.5-8.5 | 500 | 250 | 250 | 10 | |
| **Montana HHS** | | | | | | |

**Surface Water Field Measurements**

| Sample ID | pH (SU) | SC (mS) | Stream Flow (cfs) |
|---|---|---|---|
| 29-451-SW1 | 7.60 | 0.145 | 29 |
| 29-451-SW2 | 8.14 | 0.10 | 25 |
| 29-451-SW3 | 7.77 | 0.61 | ~1-2 gpm |
| 29-451-GW1 | 7.14 | 0.29 | - |
| 25-179-GW2 | 7.36 | 0.38 | - |

NA = Not analyzed; * = Based on hardness of 100 mg/L $CaCO_3$ equivalent; ** = Montana HHS for groundwater based on dissolved metal concentration only

**LEGEND**

29-451-SW1 collected 7/29/04 from Mill Creek approximately 100 feet upstream of point where former bridge crossed creek (UTM coord: 411281E; 5035381N)

29-451-SW2 collected 7/29/04 from Mill Creek approximately 20 feet downstream of TP4 tailings area (UTM coord: 411137E; 5035380N)

29-451-SW3 collected 7/29/04 from spring located ~30'-40' to west of gravel road approximately 0.2 miles north of gate into northern portion of Buckeye Mine (UTM coord: 411409E; 5036015N)

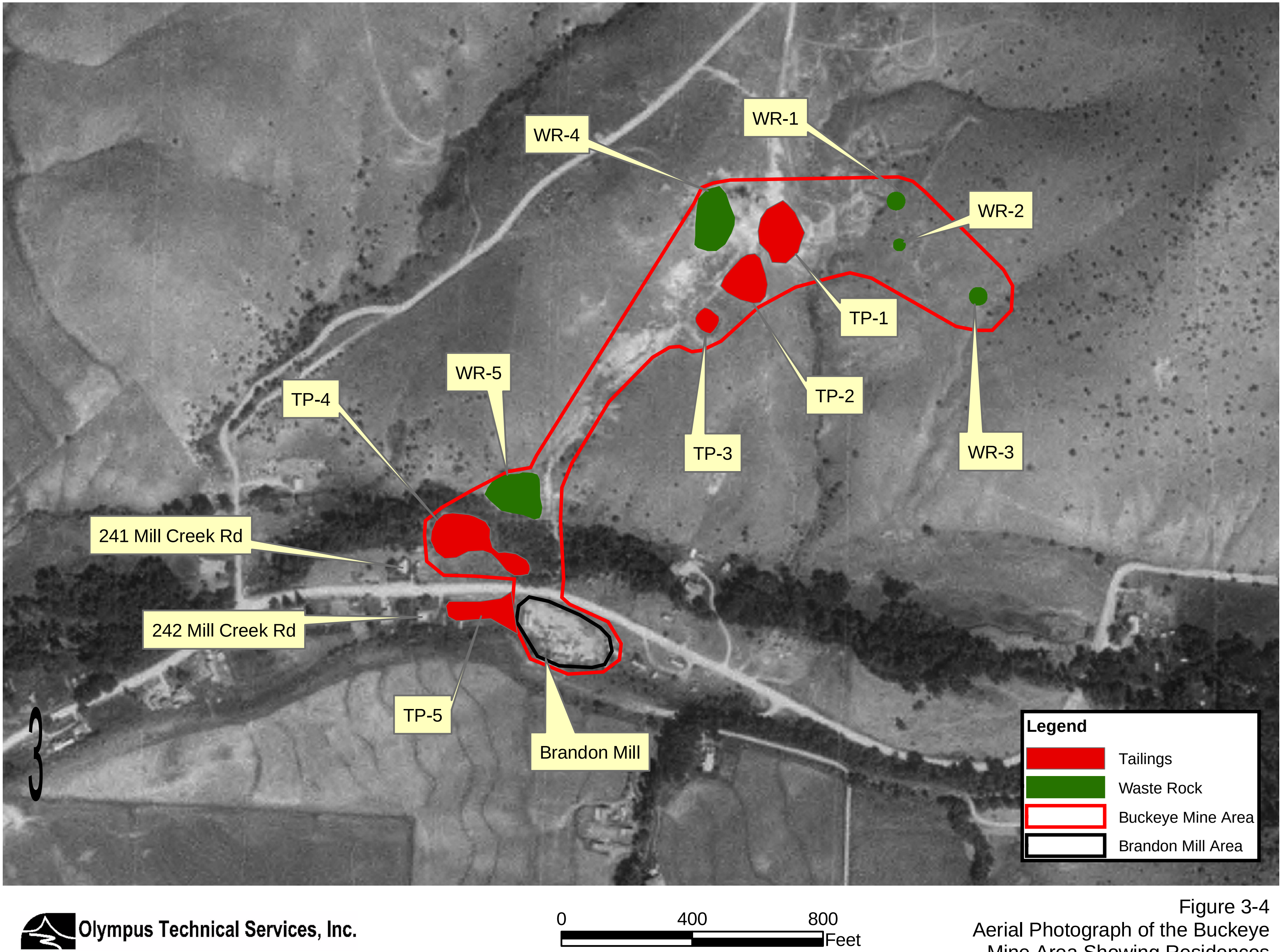
29-451-GW1 collected 7/29/04 from kitchen faucet of residence located immediately to the west of tailings pile TP4

29-451-GW2 collected 7/29/04 from bleeder valve located near well head in well pumphouse at residence immediately to the west of tailings pile TP5

Federal MCL = Federal primary and secondary maximum contaminant level based on total recoverable metal concentration; Drinking Water Standards and Health Advisories, EPA October 1996

Montana HHS = Montana human health standard based on dissolved metal concentration; Circular WQB-7 Montana Numeric Water Quality Standards, January 2002

Chronic/Acute ALS = Chronic and acute aquatic life standards based on a hardness of 100 mg/l $CaCO_3$; Circular WQB-7 Montana Numeric Water Quality Standards, January 2002




Olympus Technical Services, Inc.

Figure 3-4
Aerial Photograph of the Buckeye Mine Area Showing Residences

As part of the site characterization work on the Buckeye Mine site, the two private residential wells near mill tailings waste areas were sampled on July 29, 2004 for water quality. In both cases, the owners of the wells were notified and access was granted for water quality sampling. The residential wells are located at the following street addresses: 241 and 242 Mill Creek Road. The well depths are reported by Mr. Garner to be ±30 feet (241 Mill Creek Road) and 27 feet (242 Mill Creek Road) and the wells are housed in small wooden buildings adjacent to the residences. A search of the wells located in Section 19, Township 4 South and Range 4 West that are registered in the Montana Bureau of Mines and Geology Groundwater Information Center database was not successful in identifying these wells. It may be possible that they were drilled and registered by a previous owner. The following is the contact information for these residences:

Angela McCarthy (Renter)
241 Mill Creek Road
Sheridan, MT 59749
Rich Lewis (owner) – Sheridan, MT

Bill and Kaiti Garner (Owners)
242 Mill Creek Road
Sheridan, MT 59749

The well house was locked and the renter at 241 Mill Creek Road did not have a key. She contacted the owner of the residence and he said to collect the water sample from an outlet in the house. The water samples (29-451-GW1) were collected from the kitchen sink faucet at the 241 Mill Creek Road site after letting the water discharge for a period of time prior to sampling. The water samples (29-451-GW2) at the Garner residence (242 Mill Creek Road) were collected from a bleeder valve faucet in the well house near the well head. At the latter location, the well water discharges through a filter (reportedly for particulates only) at the well head prior to the faucet discharge point.

The water samples were analyzed at Energy Laboratories, Inc. for the following parameters: total recoverable metals (Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, and Zn), total cyanide, pH, total dissolved solids, sulfate, chloride, nitrate + nitrite as N and hardness as $CaCO_3$. The analytical results for water samples 29-451-GW1 and 29-451-GW2 are summarized in Table 3-9.

The analytical results indicate that cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) were detected in the 241 Mill Creek Road well and only zinc (Zn) was detected in the 242 Mill Creek Road well. The total recoverable Cd concentration of 0.007 mg/L detected in the 241 Mill Creek Road exceeds the Federal safe drinking water standard maximum contaminant level (MCL) of 0.005 mg/L. The other metals are within Federal drinking water standards. Total cyanide was not detected above the lower detection limit of 5 µg/L. The somewhat diverse metal suite detected in the 241 Mill Creek Road well is not unlike that detected in the chemistry results for the Buckeye Mine site waste sources, with the exception of lead (Pb). Lead is one of the principal contaminants identified in the Buckeye Mine site waste sources. Lead mobility is generally limited in natural waters due to the fact that it readily undergoes cation exchange with clays in soils. Field screening XRF results seem to corroborate this in that Pb is a significant contaminant source in the Buckeye Mine site wastes, but exhibits very limited mobility into the native soils analyzed beneath the wastes. Zinc, however, does show mobility and cadmium has been shown to be geochemically correlated with Zn in the quantitative laboratory analyses of the wastes. At this point, we know nothing about the plumbing system in the home. Piping in the home, in some cases, can contribute metal contamination of water supplies. A common source for Zn and Cd is galvanized pipes.

## 3.4 STREAM SEDIMENT CHARACTERIZATION

Two stream sediment samples were collected at the same locations as the surface water samples from Mill Creek. Stream sediment samples 29-451-SE1 and 29-451-SE2 were collected from Mill Creek to assess potential sediment impact from the Buckeye mine/mill waste sources (Figure 3-3). The background sample, SE1, was collected approximately 100 feet upstream from where the former bridge crossed Mill Creek to allow road access from the mine to the mill area. The sample is upstream of the waste sources associated with the Buckeye Mine site. Stream sediment sample site SE2 is located downstream of the Buckeye Mine waste sources and is approximately 20 feet downstream of tailings pile TP-4.

The stream sediment samples were analyzed at Energy Laboratories, Inc. for the following parameters: Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Zn and pH. The stream sediment analytical results are summarized in Table 3-10.

No metal/metalloid in the stream sediments is greater than three times the mean background native soil. The only metals that show an increase in concentration from the upstream to the downstream site relative to the Buckeye Mine area are Ba (1.02x), Cr (1.1x), Ni (1.1x), Pb (3.6x), and Zn (1.3x). Although the overall concentrations of these metals are low, the results do suggest some metal loading from waste sources to Mill Creek. Metal loading is likely related to stormwater/snowmelt runoff events as discussed earlier.

## 3.5 ASSESSMENT OF AIRBORNE PARTICULATE EMISSIONS

The principal waste sources in the Buckeye Mine site are mill tailings, waste rock piles and impacted native soils (primarily in the Brandon Mill waste area). Waste rock pile gradations are typically coarse grained containing abundant rock material. These waste sources thus contain lesser fine sediment that could be a source for airborne particulate emissions. The mill tailings typically are very fine grained to fine grained and consist of silt, sand and clay. The near surface tailings may exhibit floury textures which when disturbed create dust emissions. Although some of the tailings have vegetation, there are significant areas of exposed tailings with little to no vegetation cover. Although the volume of tailings located in the Brandon Mill area is low, fine grained tailings have mixed with near surface native soils and impacted these soils with elevated metal/metalloid concentrations. Laboratory chemistry results for composite tailings indicate that they contain a polymetallic suite. Laboratory analytical results indicate that a number of elements of environmental concern may be significantly elevated above background soil concentrations in the tailings and these include Ag, As, Cd, Cu, Hg, Pb, Sb and Zn. The range of concentrations for these parameters in each of the tailings areas is summarized in Table 3-11. Although there is some controlled vehicle access because of fencing and gates for all of the tailings piles except TP-5, the tailings are generally accessible via foot traffic. Tailings piles TP-4, TP-5 and the Brandon Mill area are generally barren of vegetation and contain the most elevated concentrations of potential airborne contaminants. These waste sources are also located nearest to residential areas.

## 3.6 ASSESSMENT OF PHYSICAL HAZARDS

The physical hazards in the Buckeye Mine site are limited. There appears to have been work done to eliminate physical hazards in much of the northern portion of the Buckeye Mine

**Table 3-10. Laboratory Chemistry Results for Stream Sediments**

| Sample ID | pH (SU) | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Pb (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-451-SE1 | 6.9 | <5 | <5 | 20.9 | <1 | 24.6 | 32.9 | 10300 | <5 | <1 | 202 | 16.5 | <5 | 15.3 |
| 29-451-SE2 | 6.9 | <5 | <5 | 21.3 | <1 | 26.0 | 14.5 | 8570 | 8.9 | <1 | 165 | 17.7 | <5 | 20.0 |
| Ratio Downstream/Upstream | 1.0 | 1.0 | 1.0 | 1.02 | 1.0 | 1.1 | 0.4 | 0.8 | 3.6 | 1.0 | 0.8 | 1.1 | 1.0 | 1.3 |

**LEGEND**

29-451-SE1 collected 7/29/04 from Mill Creek approximately 100 feet upstream of point where former bridge crossed creek (UTM coord: 411281E; 5035381N)
29-451-SE2 collected 7/29/04 from Mill Creek approximately 20 feet downstream of TP4 tailings area (UTM coord: 411137E; 5035380N)

**Table 3-11. Summary of the Range of Metal/Metalloid Concentrations in Mill Tailings**

| | Range of Concentration (mg/Kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tailings Area** | **Ag** | **As** | **Cd** | **Cu** | **Hg** | **Pb** | **Sb** | **Zn** |
| TP-1 | <5-15.4 | 45.1-206 | 2.9-9.7 | 94.1-522 | <1 | 281-1,990 | <5-13.4 | 494-1,920 |
| TP-2 | <5 | 6.5-9.7 | 1.4-1.6 | 54.4-62.4 | <1 | 97-109 | <5 | 328-394 |
| TP-3 | <5-59.7 | 5.6-508 | 1.1-6.9 | 40.2-1,430 | <1 | 86.5-5,510 | <5 | 189-412 |
| TP-4 | 15.5-60.1 | 143-338 | 23.1-79.3 | 472-1,980 | <1-3.3 | 1,640-7,750 | 11.5-49.9 | 3,500-12,500 |
| TP-5 | 11.8-22.7 | 106-222 | 6.6-15.4 | 287-458 | <1-2.5 | 1,440-2,900 | <5-11.7 | 1,070-2,850 |
| Brandon Mill Area | 49.9-268 | 295-455 | 5.0-16.8 | 505-961 | <1-2.6 | 7,240-43,400 | 12.8-32.4 | 1,010-2,830 |

site since the cultural resources and inventory assessment completed in 2003 (Frontier Historical Consultants, 2003). Most of the open mine workings described in this report are no longer accessible because they have been backfilled. The two mill buildings have been dismantled and the only structures remaining in the former mill area in the northern portion of the project are two small wooden buildings with metal siding, a wooden headframe with ore bin, wooden loading platform, wooden stairway, concrete pad and minor miscellaneous metal and wood debris. The buildings and headframe are generally structurally sound and do not appear to be in danger of collapse. The wooden stairway is a physical hazard due to the structural integrity. There is a spur powerline and transformer which likely provided power to the former mill and this is located near the wooden headframe. It is unknown whether the power has been cutoff or the transformer contains polychlorinated biphenols (PCBs) oil.

All of the adits associated with the waste rock piles are collapsed and non-accessible with the exception of an open hole into the underground near the gossan outcrop area and an open adit with wooden door located approximately 200 feet northeast of waste rock pile WR-5. These are potential physical hazards for they provide access into the former underground mine workings in these areas.

The former Brandon Mill area is evidenced by the remaining rock foundation walls on the side of the hill. The main foundation wall in the former mill area is approximately 30 feet long and 8 feet high and could constitute a fall hazard. The five abandoned house trailers are dilapidated and contain much broken glass and nails constituting physical hazards. Probably the greatest hazard associated with these structures is biological due to the potential for hanta virus. These dilapidated trailers contain abundant mice feces. The presence of numerous lead-acid batteries and two 55-gallon drums, partially filled with unknown liquids, present potential chemical hazards. Although the two fuel tanks and a propane bottle located in the Brandon Mill appear to be empty, none of these containers were accessed to evaluate whether residual products are present.

## 3.7 POTENTIAL REPOSITORY SITE INVESTIGATION

The Buckeye Mine site is located at the southwestern edge of the Tobacco Root Mountains near the area where Mill Creek discharges into the terraced valley northeast of Sheridan, Montana. The northern portion of the site is located in a moderately steep, narrow and mountainous ephemeral drainage basin, while the southern portion is located in the relatively flat floodplain of Mill Creek. Land ownership in the project area is mostly private on patented mining claims and these claims are generally bordered by public lands administered by the U.S. Bureau of Land Management (BLM). During the site characterization, a potential mine/mill waste repository site was investigated in the northern portion of the Buckeye Mine site. This work involved assessing land ownership, estimating potential repository storage volume and preliminary design, construction logistics, and an evaluation of the subsurface geology and shallow groundwater.

Site characterization results indicate that the mill tailings (TP-1 through TP-5), waste rock piles (WR-1 through WR-5), and the Brandon Mill area wastes comprising impacted soils with lesser tailings and partially processed ore represent the most significant source of contaminants for impacting human health and the environment. The total estimated volume of the wastes associated with the Buckeye Mine is approximately 24,069 cubic yards.

Figures 3-5 and 3-6 show the potential repository site area, existing topography and preliminary repository design. This area was selected largely because it is an area on a relatively flat ridgeline and is strategically located to potential haul roads for transporting the wastes. The base of the repository would be constructed subgrade along the ridge top after the excavation of borrow source cover soils. The potential to use the same site for the cover soil borrow source and repository is advantageous for it would limit the land disturbance and provide for cost efficient construction. The borrow source and repository site would be located within the Buckeye patented claim owned by Victoria Mines, Inc.

The preliminary design indicates that the repository would occupy approximately 1.5 acres, have an average thickness of 11.6 feet, a maximum waste thickness of 16 feet, and a total repository height of 45 feet. The preliminary repository volume is estimated at 28,400 cubic yards. This is enough storage volume to contain the mill tailings, waste rock and impacted soils.

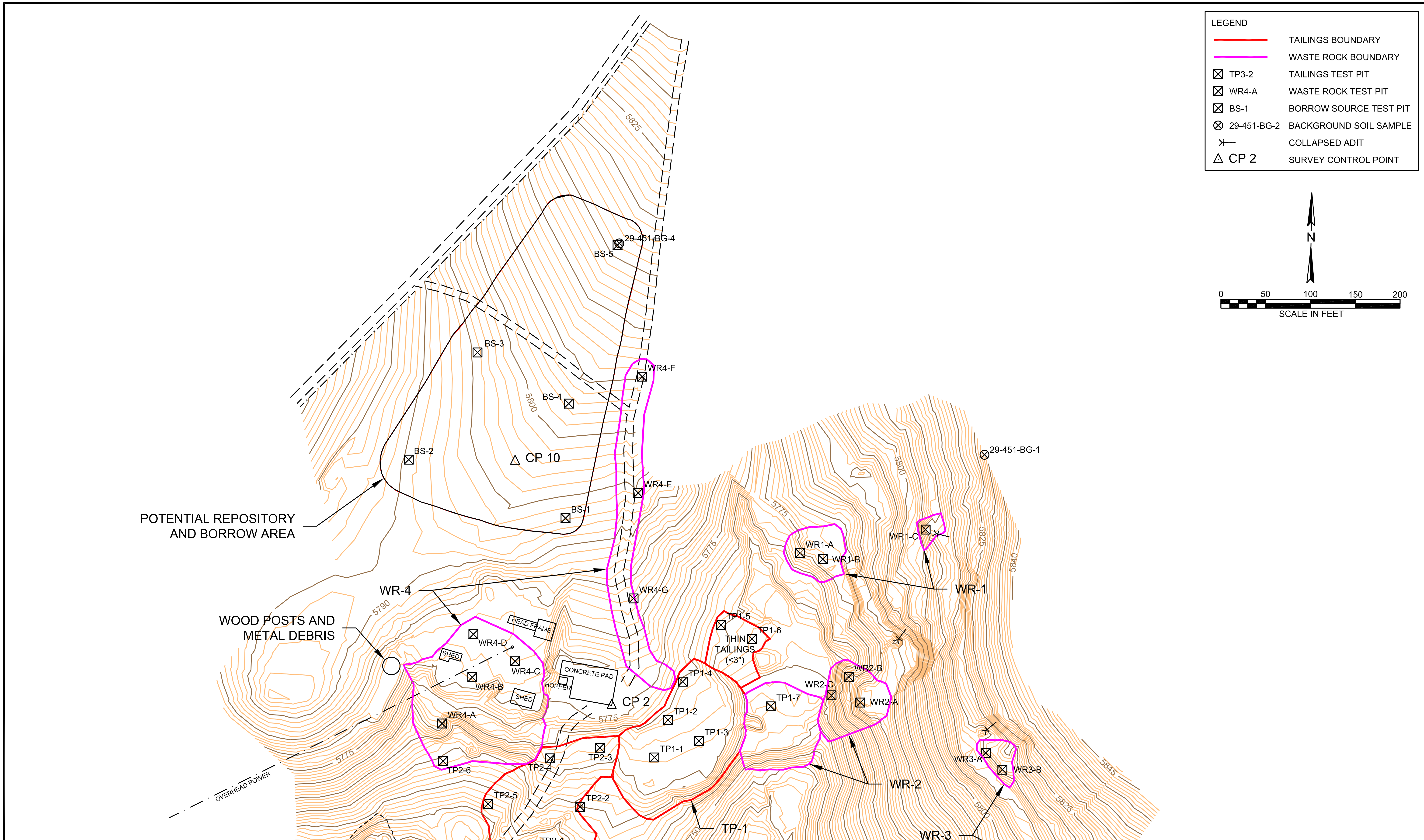
With the exception of slight moisture intersected below 4.0 feet in test pit BS-3, no other water was observed in the repository test pits. The geology of the repository area from the surface to depth consists of a thin topsoil layer, followed by light brown silty sand to sandy silt grading down to slightly oxidized, coarse sand and finally rock, probably bedrock. The maximum depth of unconsolidated materials was in test pit BS-3 where the total depth below ground surface was 11.3 feet. Shallow bedrock generally correlates with the ridge axis.

Subsurface composite soil samples of silty sand and silty clay to clayey silt were collected from test pits for future analysis of geotechnical parameters. These data would be required for the final repository design.

## 3.8 POTENTIAL BORROW SOURCE INVESTIGATION

Viable cover soil borrow sources do not appear to be an issue in the Buckeye Mine site area. A potential borrow source area was evaluated in the northern portion of the site. This area is nearly bisected by the northwest-southeast access road into the northern-most mill site associated with the Buckeye Mine (Figure 3-5). Five backhoe test pits (BS-1 through BS-5) were excavated to assess the potential cover soil borrow source. The test pit and detailed topographic survey data were used to evaluate the depth and thickness of the native soil and to estimate the volume potential of 18,730 cubic yards. The potential borrow source area base topography and depth contours are presented in Figure 3-7.

Two composite native soil samples, 29-451-BS-1 and 29-451-BS-2, were collected to evaluate selected physical and chemical properties of the potential cover soil borrow source. Revegetation and particle size analytical results are summarized in Table 3-12. The revegetation and particle size results indicate that the soils would meet the cover soil specifications (MDSL/AMRB, 1991) with the exception of organic matter content. The organic matter contained in the soils is 0.40 weight percent (wt. %). Some organic amendment may be required if this material were used as cover soil. To further assess the native soil potential as cover soil, quantitative laboratory analyses of the samples were done. The representative composite soil samples were analyzed for Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb and Zn. The laboratory results are summarized in Table 3-12. The chemical results for this potential borrow source cover soil are comparable to the mean background soil concentrations determined for the Buckeye Mine site.




| NO. | REVISION DESCRIPTION | BY | DATE |
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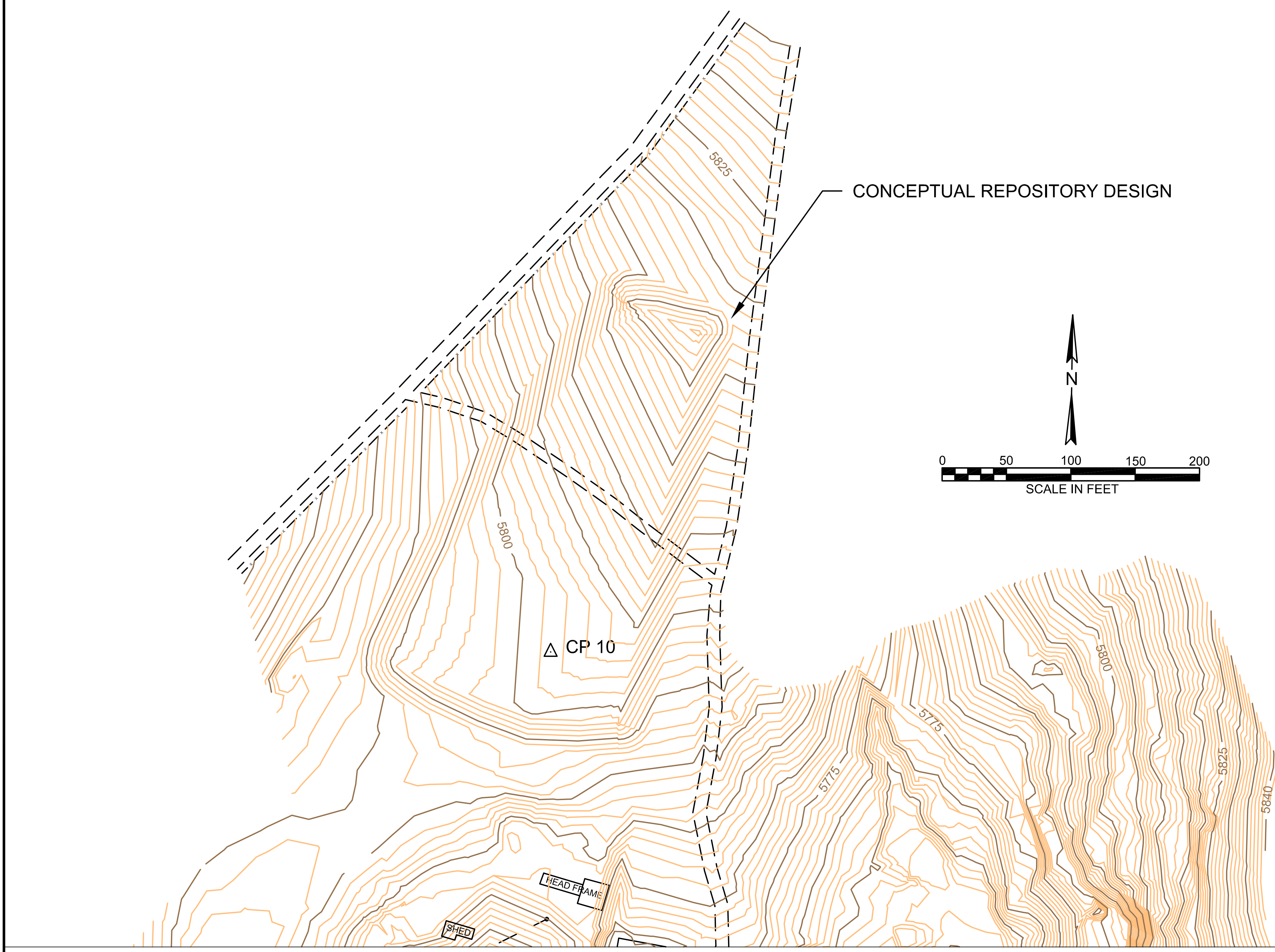
|---|---|---|
| DESIGN: | DRAWN: KSR | CHECKED: CRS |
| APPROVED: | DATE: 4/2005 | JOB NO: A1475 |
| SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg | |

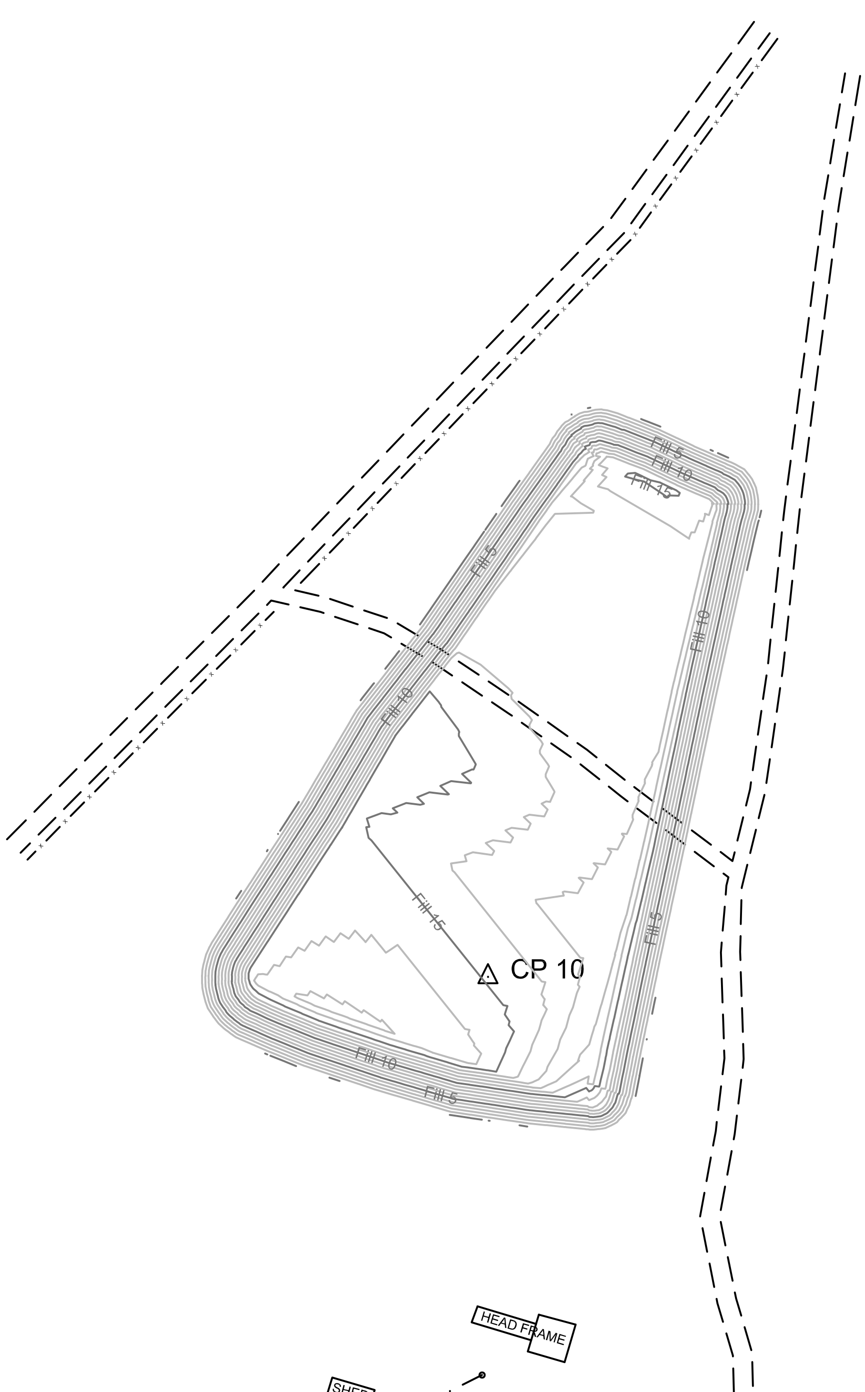
MONTANA DEQ/MINE WASTE CLEANUP BUREAU
BUCKEYE MINE SITE
MADISON COUNTY, MONTANA

Olympus Technical Services, Inc.

BUCKEYE MINE SITE
POTENTIAL COVER SOIL BORROW SOURCE AND REPOSITORY AREA

FIGURE 3-5

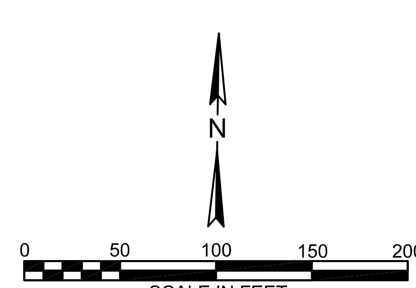



Prismoidal Volume Results

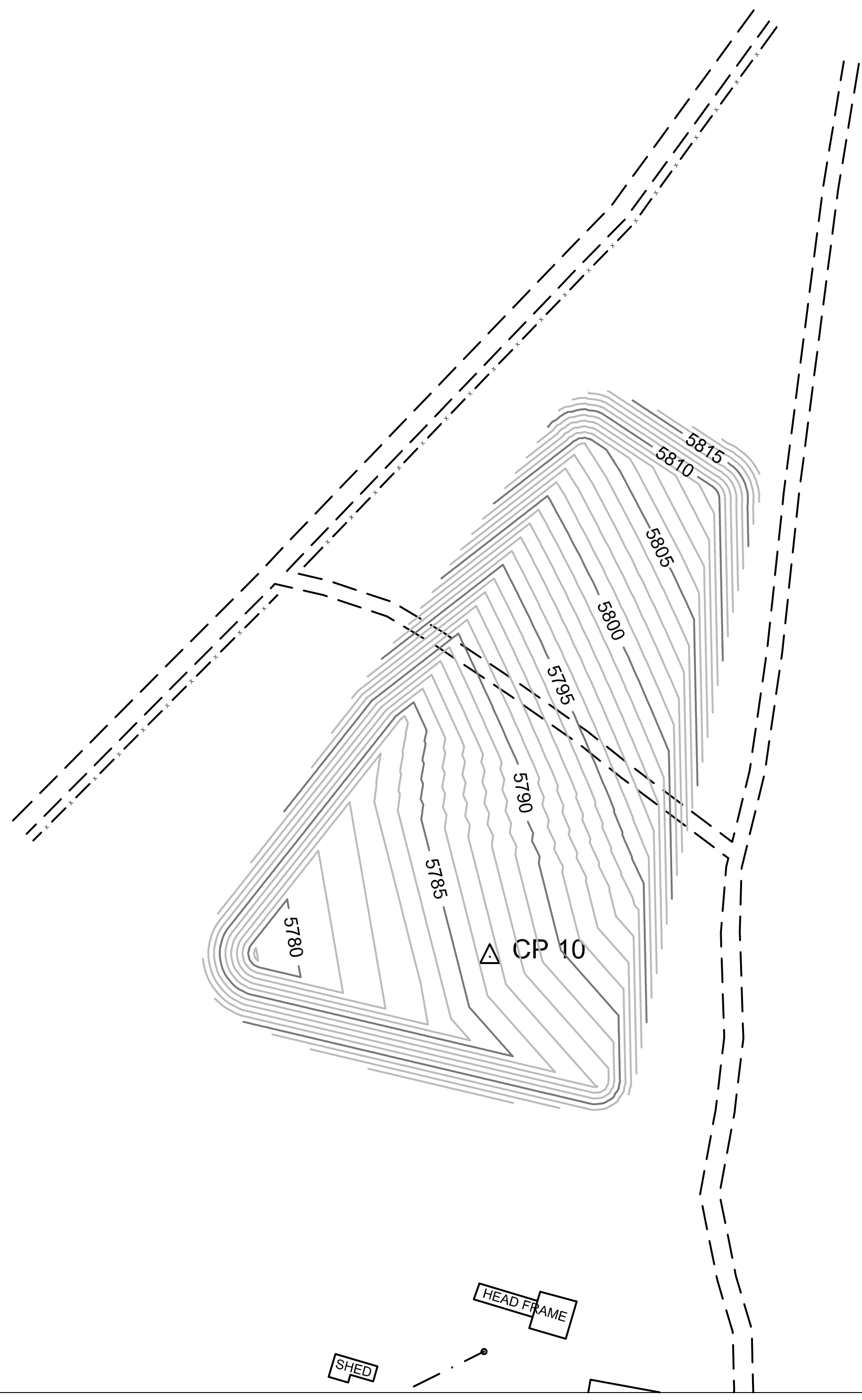
| | |
|---|---|
| Original Surface Model: | ReposBase |
| Final Surface Model: | ReposTop |
| Cut Compaction Factor: | 0.00 % |
| Fill Compaction Factor: | 0.00 % |
| Raw Cut Volume: | 0 cu yd |
| Compacted Cut Volume: | 0 cu yd |
| Total Cut Volume: | 0 cu yd |
| Raw Fill Volume: | 28388 cu yd |
| Compacted Fill Volume: | 0 cu yd |
| Total Fill Volume: | 28388 cu yd |

REPOSITORY DEPTH CONTOURS

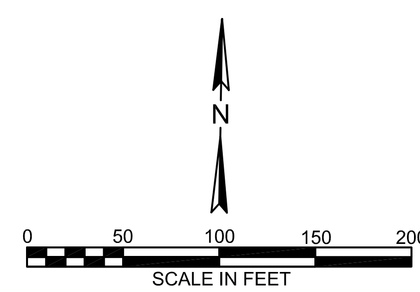


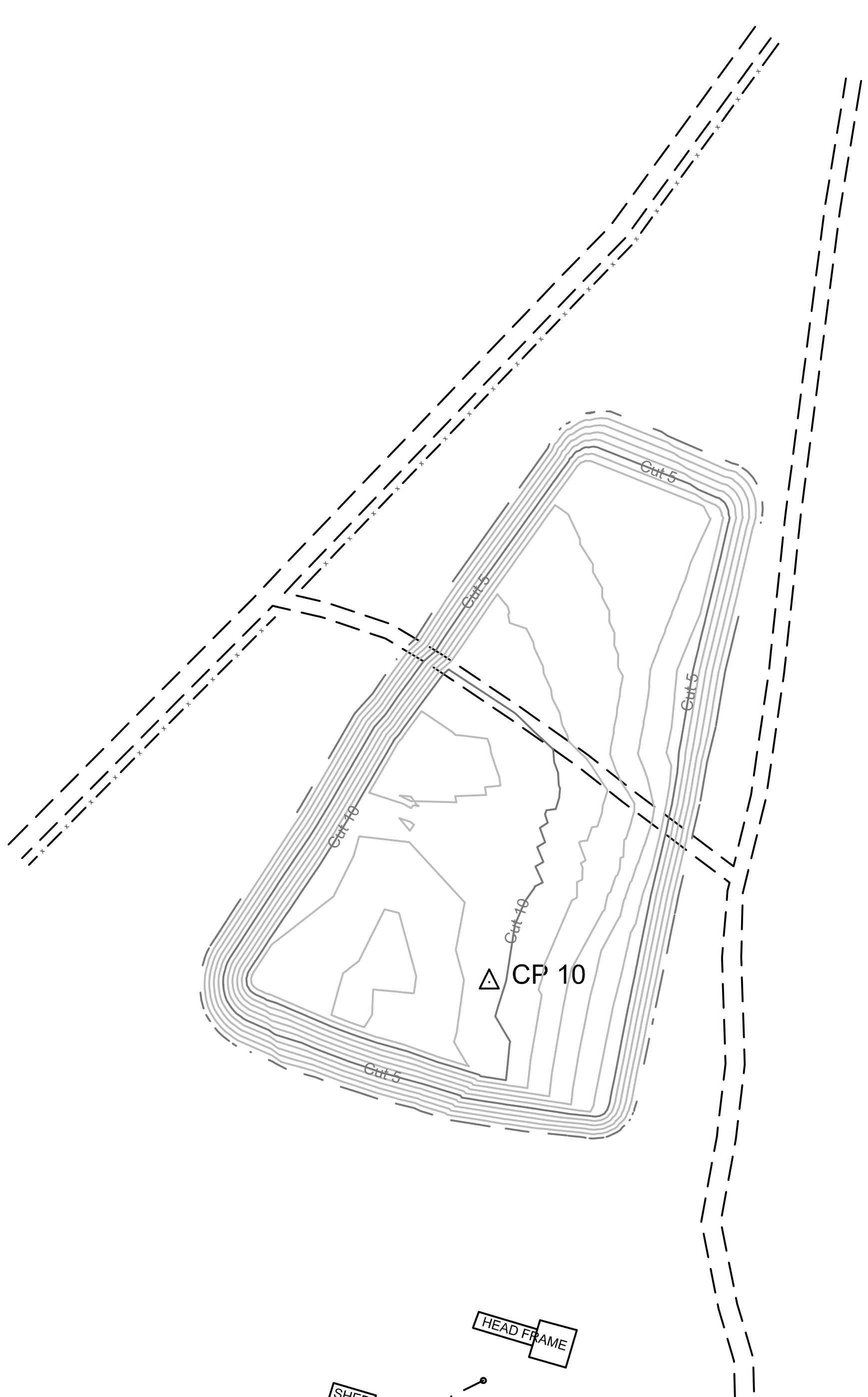

| Olympus Technical Services, Inc. | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE SITE<br>MADISON COUNTY, MONTANA | BUCKEYE MINE SITE<br>CONCEPTUAL REPOSITORY<br>DESIGN AND DEPTH CONTOURS | FIGURE<br>3-6 |
|---|---|---|---|

| DESIGN: | DRAWN: KSR | CHECKED: CRS | APPROVED: | DATE: 4/2005 | JOB NO: A1475 | SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg |
|---|---|---|---|---|---|---|---|




POTENTIAL REPOSITORY AND BORROW
SOURCE AREA BASE TOPOGRAPHY

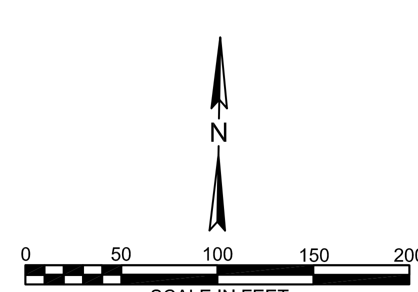



Prismoidal Volume Results

| | |
|---|---|
| Original Surface Model: | Existing |
| Final Surface Model: | ReposBase |
| Cut Compaction Factor: | 0.00 % |
| Fill Compaction Factor: | 0.00 % |
| Raw Cut Volume: | 18726 cu yd |
| Compacted Cut Volume: | 0 cu yd |
| Total Cut Volume: | 18726 cu yd |
| Raw Fill Volume: | 0 cu yd |
| Compacted Fill Volume: | 0 cu yd |
| Total Fill Volume: | 0 cu yd |

POTENTIAL BORROW SOURCE
DEPTH CONTOURS




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Olympus Technical Services, Inc. | | | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE SITE<br>MADISON COUNTY, MONTANA | | | POTENTIAL BORROW SOURCE<br>AREA BASE TOPOGRAPHY<br>AND DEPTH CONTOURS | FIGURE<br>3-7 |
| DESIGN: | DRAWN: KSR | CHECKED: CRS | APPROVED: | DATE: 4/2005 | JOB NO: A1475 | SCALE: AS SHOWN | FILENAME: A1475Buckeye.dwg |

**Table 3-12. Laboratory Borrow Source Cover Soil Revegetation, Particle Size and Chemistry Results**

| | Physical Characteristics | | | | Chemical Characteristics | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Sand (wt%) | Silt (wt%) | Clay (wt%) | Texture* | pH (S.U.) | Conductivity, Saturated Paste (mmhos/cm) | Saturation (wt%) | Organic Matter (wt%) | Phosphorus mg/Kg | Nitrate as N (KCL extract) mg/Kg | Potassium mg/Kg |
| 29-451-BS-1 | 48 | 35 | 17 | L | 8.0 | 10.0 | 33.4 | 0.40 | 13 | <1 | 19 |
| 29-451-BS-2 | 30 | 52 | 18 | SiL | 8.0 | 8.77 | 41.4 | 0.40 | 14 | <1 | 52 |

*C=Clay, S=Sand(y), Si=Silt(y), L=Loam(y)

**Cover Soil Particle Size Results**

| | Weight Percent Retained | | | | | Percent Finer by Weight | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Gravel | Sand | | | Silt/Clay | Gravel | Sand | | | Silt/Clay |
| Sieve Size | 3/4-in | #4 | #10 | #40 | #200 | 3/4-in | #4 | #10 | #40 | #200 |
| Opening (Inches) | 0.75 | 0.187 | 0.0661 | 0.0106 | 0.0029 | 0.75 | 0.187 | 0.0661 | 0.0106 | 0.0029 |
| 29-451-BS-1 | <0.1 | 1.9 | 7.2 | 17.1 | 17.2 | 100 | 98.1 | 90.9 | 73.8 | 56.6 |
| 29-451-BS-2 | <0.1 | <0.1 | 0.2 | 2.4 | 16.0 | 100 | 100 | 99.8 | 97.4 | 81.4 |

**Cover Soil Metal/Metalloid Chemistry Results**

| Sample ID | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-451-BS-1 | <5 | 5.7 | 146 | <1 | 19.0 | 49.3 | 17800 | <1 | 352 | 17.0 | 36.9 | <5 | 116 |
| 29-451-BS-2 | <5 | <5 | 178 | <1 | 23.1 | 21.9 | 15700 | <1 | 418 | 18.8 | 22.5 | <5 | 67 |
| Maximum | <5 | 5.7 | 178 | <1 | 23.1 | 49.3 | 17800 | <1 | 418 | 18.8 | 36.9 | <5 | 116 |
| Minimum | <5 | <5 | 146 | <1 | 19 | 21.9 | 15700 | <1 | 352 | 17 | 22.5 | <5 | 67 |
| Mean | | 4.1 | 162.0 | | 21.05 | 35.60 | 16750.0 | | 385.0 | 17.90 | 29.70 | | 91.5 |
| # of Samples | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Mean Background | 2.5 | 9.0 | 167.3 | 0.50 | 21.7 | 40.2 | 17100.0 | 0.50 | 396.0 | 18.2 | 32.1 | 2.5 | 99.7 |

Note: Statistics - one half the lower detection limit is used where below detection limit samples are included in the mean calculation

**LEGEND**

29-451-BS-1 is a composite of BS-1-0-4.0; BS-5-0-3.6; BS-4-0-3.4

29-451-BS-2 is a composite of BS-2-0-11.7; BS-3-0-11.9; BS-5-3.6-6.3

## 4.0 SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The summary of the applicable or relevant and appropriate requirements (ARARs) was compiled from a draft document describing ARARs for abandoned mine sites produced by the Montana Department of Environmental Quality - Mine Waste Cleanup Bureau (DEQ-MWCB). These ARARs, along with those prepared by ARCO for the Streamside Tailings Operable Unit (ARCO, 1995) and the Montana Department of Environmental Quality-Hazardous Waste Site Cleanup Bureau for mine sites, were reviewed by Olympus to develop a listing of potential federal and state ARARs for the Buckeye Mine site. The federal and state ARARs are summarized in Table 4-1 and Table 4-2, respectively. Appendix B provides detailed descriptions of potential federal and state ARARs. The description of the federal and state ARARs includes summaries of legal requirements that, in many cases, attempt to set out the requirement in a simple fashion useful in evaluating compliance with the requirement. In the event of any inconsistency between the law itself and the summaries in this section, the ARAR is ultimately the requirement as set out in the law, rather than any paraphrase provided here.

**TABLE 4-1. SUMMARY OF PRELIMINARY FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS.**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| **FEDERAL CONTAMINANT-SPECIFIC** | | | |
| Safe Drinking Water Act | 42 USC §§ 300f | | |
| National Primary Drinking Water Standards | 40 CFR Part 141 | Establishes health-based standards (MCLs) for public water systems. | Relevant and Appropriate |
| National Secondary Drinking Water Standards | 40 CFR Part 143 | Establishes welfare-based standards (secondary MCLs) for public water systems. | Relevant and Appropriate |
| Clean Water Act | 33 USC § 1251-1375 | | |
| Water Quality Standards | 40 CFR Part 131 | Sets criteria for water quality based on toxicity to aquatic organisms and human health. | Applicable |
| National Pollutant Discharge Elimination System (NPDES) | 40 CFR Part 122 | General permits for discharge from construction. | Applicable |
| Clean Air Act | 42 USC § 7409 | | |
| National Primary and Secondary Ambient Air Quality Standards | 40 CFR Part 50 | Air quality levels that protect public health. | Applicable |
| Resource Conservation and Recovery Act | 42 USC § 6901 | | |
| Lists Of Hazardous Waste | 40 CFR Part 261, Subpart D | Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270 and 271. | Applicable |

## TABLE 4-1. SUMMARY OF PRELIMINARY FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| **FEDERAL LOCATION-SPECIFIC** | | | |
| National Historic Preservation Act | 16 USC § 470;<br>36 CFR Part 800;<br>40 CFR §6.301(b) | Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking. | Applicable |
| Archaeological and Historic Preservation Act | 16 USC § 469;<br>40 CFR § 6.301(c) | Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program. | Applicable |
| Protection of Wetlands Order | 40 CFR Part 6, Appendix A, Executive Order No. 11,990 | Avoid adverse impacts associated with destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists. | Applicable |
| Historic Sites, Buildings and Antiquities Act | 16 USC §§ 461-467;<br>40 CFR § 6.301(a) | Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks. | Applicable |
| Fish and Wildlife Coordination Act | 16 USC §§ 661 et seq.;<br>40 CFR § 6.302(g) | Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources. | Applicable |
| Floodplain Management Order | 40 CFR Part 6 Executive Order No. 11,988 | Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct development of a floodplain. | Applicable |

# TABLE 4-1. SUMMARY OF PRELIMINARY FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Endangered Species Act | 16 USC §§ 1531-1543;<br>40 CFR § 6.302(h);<br>50 CFR Part 402 | Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat. | Applicable |
| Bald Eagle Protection Act | 16 USC §§ 668 | Requires consultation with the USFWS during reclamation design and construction to ensure that any cleanup of the site does not unnecessarily adversely affect the Bald Eagle or Golden Eagle. | Applicable |
| Migratory Bird Treaty Act | 16 USC §§ 703 | Establishes a federal responsibility for the protection of the international migratory bird resource and requires consultation with the USFWS during reclamation design and construction to ensure the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement. | Applicable |
| **FEDERAL ACTION-SPECIFIC** | | | |
| Clean Water Act | 33 USC § 1342 | | |
| National Pollutant Discharge Elimination System (NPDES) | 40 CFR Part 122 | Requires permits for the discharge of pollutants from any point source into waters of the United States. | Relevant and Appropriate |
| Surface Mining Control and Reclamation Act | 30 USC §§ 1201-1328 | Protects the environment from effects of surface mining activities. | Relevant and Appropriate |
| | 30 CFR Part 784 | Governs underground mining permit applications and minimum requirements for reclamation and operations plans. | Relevant and Appropriate |

## TABLE 4-1. SUMMARY OF PRELIMINARY FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Surface Mining Control and Reclamation Act (continued) | 30 CFR Part 816 | Outlines permanent program performance standards for surface mining activities. | Relevant and Appropriate |
| Hazardous Materials Transportation Regulations | 49 USC §§ 5101-5105 | | |
| Standards Applicable to Transporters of Hazardous Waste | 49 CFR Part 10 | Regulates transportation of hazardous waste. | Relevant and Appropriate |
| Resource Conservation and Recovery Act | | | |
| Land Disposal | 40 CFR Part 268 | Establishes a timetable for restriction of burial of wastes and other hazardous materials. | Applicable |
| Criteria for Classification of Solid Waste Disposal Facilities and Practices | 40 CFR Part 257 | Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby constitute prohibited open dumps. | Applicable |
| Standards for Transporters of Hazardous Waste | 40 CFR Part 263 | Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262. | Applicable |
| Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities | 40 CFR Part 264 | Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste. | Applicable |

**TABLE 4-1. SUMMARY OF PRELIMINARY FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| <u>Occupational Safety And Health Act</u> | 29 USC § 655 | | |
| Hazardous Waste Operations and Emergency Response | 29 CFR 1910.120 | Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & emergency response. | Applicable |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| **STATE CONTAMINANT-SPECIFIC** | | | |
| Montana Water Quality Act | 75-101 et seq., MCA | Laws to prevent, abate, and control the pollution of state waters. | Applicable |
| Regulations Establishing Ambient Surface Water Quality Standards | ARM 17.30.606-630 | Provides the water use classification for various streams and imposes specific water quality standards per classification. | Applicable |
| Regulations Establishing Ambient Surface Water Quality Nondegradation Standards | ARM 17.30.705-717 | Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to State waters and outlines review procedures. | Applicable |
| | ARM 17.30.1203 | Technology-based treatment for MPDES permits. | Applicable |
| Montana Groundwater Pollution Control System Regulations | ARM 17.30.1006 | Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and establishes groundwater classification standards. | Applicable |
| Public Water Supplies Act | 75-6-101, MCA | Establishes public policy of MT to protect, maintain, and improve the quality and potability of water for public water supplies and domestic uses. | Relevant and Appropriate |
| Public Water Supply Regulations | ARM 17.30.204 | Establishes maximum contaminant levels (MCLs) for inorganic chemicals in community water systems. | Relevant and Appropriate |
| | ARM 17.30.205 | Establishes the maximum turbidity contaminant levels for public water supply systems which use surface water in whole or in part. | Relevant and Appropriate |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Clean Air Act Of Montana | 75-2-101 MCA | Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property. | Relevant and Appropriate |
| Air Quality Regulations | ARM 17.8.222 | No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air. | Applicable |
| | ARM 17.8.220 | No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter. | Applicable |
| | ARM 17.8.223 | No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standard: 1) 24-hr. avg.: 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air. | Applicable |
| | ARM 17.8.308 | States “no person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.” | Applicable |
| | ARM 17.8.304 (2) | States no person shall cause opacity of 20% or greater averaged over 6 consecutive minutes. | Applicable |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Air Quality Regulations (continued) | ARM 17.8.341 | Sets forth emission standards for hazardous air pollutants. | Applicable |
| | ARM 17.24.761 | Requires a fugitive dust control program be implemented in reclamation operations. | Applicable |
| Occupational Health Act of Montana | 50-70-101, MCA | The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety. | Applicable |
| Occupational Air Contaminants Requirements | ARM 17.74.102 | Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. | Applicable |
| Occupational Noise Regulations | ARM 17.74.101 | Addresses occupational noise levels and provides that no worker shall be exposed to noise levels in excess of specified levels. | Applicable |
| **STATE LOCATION-SPECIFIC** | | | |
| Floodplain and Floodway Management Act | 76-5-401, MCA | Lists the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment. | Applicable |
| | 76-5-402 MCA | Lists the permissible uses within the floodplain but outside of floodway. | Applicable |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Floodplain and Floodway Management Act (continued) | 76-5-403, MCA | Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods. | Applicable |
| Floodplain Management Regulations | ARM 36.15.602 | Uses allowed in the floodway which require a permit. | Applicable |
| | ARM 36.15.601 | Open space uses allowed in the floodway without a permit. | Applicable |
| | ARM 36.15.216 | The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section. | Applicable |
| | ARM 36.15.603 | Proposed diversions or changes in place of diversions must be evaluated by DNRC to determine whether they may significantly affect flood velocities. | Applicable |
| | ARM 36.15.604 | Prohibits new artificial obstructions or nonconforming uses that will significantly increase the upstream elevation of the base flood 0.5 feet or significantly increase flood velocities. | Applicable |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Floodplain Management Regulations (continued) | ARM 36.15.605 | Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway. Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited. | Applicable |
| | ARM 36.15.606 | Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, riprap, channelization projects, and dams. | Applicable |
| | ARM 36.15.701 | Describes allowed uses in the flood fringe. | Applicable |
| | ARM 36.15.703 | Prohibited uses within the flood fringe including solid and hazardous waste disposal and storage of toxic, flammable, or explosive materials. | Applicable |
| | ARM 36.15.801 | Allowed uses where the floodway is not designated or where no flood elevations are available. | Applicable |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Natural Streambed and Land Preservation Standards | 87-5-501-504, MCA | Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat. | Applicable |
| | ARM 36.2.410 | Defines project information which applicant must provide to district and provides that stream projects must be designed and constructed to minimize adverse impacts to stream, future disturbances to the stream, and erosion; temporary structures used during construction must handle reasonably anticipated high flows; channel alteration must be designed to retain original stream length or otherwise provide for hydrologic stability; streambank vegetation must be protected except where removal is necessary and riprap, rock, or other material must be sized adequately to protect streambank erosion. | Applicable |
| Antiquities Act | 22-3-424, MCA | Heritage and paleontological sites are given appropriate consideration. | Relevant and Appropriate |
| | 22-3-433, MCA | Evaluation of environmental impacts include consultation with State Historic Preservation Officer (SHPO). | Relevant and Appropriate |
| | 22-3-435, MCA | A heritage or paleontological site is to be reported to the SHPO. | Relevant and Appropriate |
| Cultural Resource Regulations | ARM 12.8.503-508 | Procedures to ensure adequate consideration of cultural values. | Relevant and Appropriate |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| **STATE ACTION SPECIFIC** | | | |
| Montana Water Quality Act | 75-5-605, MCA | Pursuant to this section, it is unlawful to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters. | Applicable |
| Montana Surface Water Quality Regulations | ARM 17.30.635 | Industrial waste must receive treatment equivalent to the best practicable available control technology. | Applicable |
| | ARM 17.30.607-629 | Provides for classification of state waters. | Applicable |
| | ARM 17.30.637 | Requires that the State's surface waters be free from, among other things, substances that will create concentrations or combinations of materials that are harmful to human, animal, plant, or aquatic life. Moreover, no waste may be discharged and no activities may be conducted that can reasonably be expected to violate any of the standards. | Applicable |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Nondegradation of Water Quality | ARM 17.30.705-717 | Applies nondegradation requirements to any activity which would cause a new or increased source of pollution to state waters and outlines review procedures. | Applicable |
| Montana Groundwater Act | | | |
| Montana Groundwater Pollution Control System Regulations | ARM 17.30.1011 | Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA, and ARM 17.30.701 et. seq. | Applicable |
| | ARM 17.30.1006 | Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and establishes groundwater classification standards. | Applicable |
| Clean Air Act Of Montana | 75-2-101 MCA | Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property. | Applicable |
| Air Quality Requirements | ARM 17.8.222 | No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air. | Applicable |
| | ARM 17.8.604 | Lists certain wastes that may not be disposed of by open burning. | Applicable |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Air Quality Requirements (continued) | ARM 17.8.308-310 | No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken. | Applicable |
| Montana Solid Waste Management Act | 75-10-201, MCA | Public policy is to control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible. | Applicable |
| Solid Waste Management Regulations | ARM 17.50.505 | The standards for solid waste disposal are set forth in this provision. | Applicable |
| | ARM 17.50.510 | General operational and maintenance requirements for solid waste management facilities. | Applicable |
| | ARM 17.50.523 | Solid waste must be transported In such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle. | Applicable |
| Montana Hazardous Waste Act and Underground Storage Tank Act | 5-10-402, MCA | It’s the policy of the State to “protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes”. | Applicable |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Montana Hazardous Waste Regulations | ARM 17.54.701,702 and 705 | By reference to federal regulatory requirements, these sections establish standards for all permitted hazardous waste management facilities.<br>1) 40 CFR 264.11 (referenced by ARM 17.54.702) establishes that hazardous waste management facilities must be closed in such a manner as to minimize the need for further maintenance and to control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or the atmosphere.<br><br>2) 40 CFR 264.228(a) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the waste management unit covered.<br><br>3) 40 CFR 264.228 and 310 (incorporated by reference by ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover; d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoil present. | Relevant and Appropriate |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Montana Hazardous Waste Regulations (continued) | ARM 17.54.701,-702 and 705 | 4) 40 CFR 264.119 (incorporated by reference in ARM 17.54.702) requires that a map be provided showing the dimensions of waste disposal units, together with the types and amounts of waste disposed of in each unit. Additionally, the owner must record a deed restriction, in accordance with state law, that will in perpetuity notify potential purchasers that the property has been used for waste disposal and that its use is restricted. | Relevant and Appropriate |
| | ARM 17.54.111-113 | Establishes permit conditions, duration of permits, schedules of compliance, and requirements for recording and reporting. | Relevant and Appropriate |
| <u>Montana Strip and Underground Mine Reclamation Act</u> | 82-4-231, MCA | Sets forth objectives that require the operator to prepare a plan and to reclaim and revegetate the land affected by his operation. | Relevant and Appropriate |
| | 82-4-233, MCA | Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands. Specifications for the vegetative cover and performance are provided. | Relevant and Appropriate |
| Backfilling and Grading Requirements | ARM 17.24.501 | Gives general backfilling and grading requirements. | Relevant and Appropriate |
| | ARM 17.24.519 | The operator may be required to monitor settling of regraded areas. | Relevant and Appropriate |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Hydrology Requirements | ARM 17.24.631 | Reclamation operations must be planned and conducted to minimize disturbance and to prevent material damage to the prevailing hydrologic balance. | Relevant and Appropriate |
| | ARM 17.24.633 | Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetated. | Relevant and Appropriate |
| | ARM 17.24.634 | Drainage design shall emphasize pre-mining channel and floodplain configurations that blend with the undisturbed drainage system above and below; and will meander naturally; remain in dynamic equilibrium with the system; improve unstable pre-mining conditions; provide for floods; provide for long term stability of landscape; and establish a pre-mining diversity of aquatic habitats and riparian vegetation. | Relevant and Appropriate |
| | ARM 17.24.635-637 | Sets forth requirements for temporary and permanent diversions. | Relevant and Appropriate |
| | ARM 17.24.638 | Sediment control measures shall be designed using the best technology currently available to prevent additional sediment to streamflows, meet the more stringent of federal or state effluent limitation, and minimize erosion. | Relevant and Appropriate |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Hydrology Requirements (continued) | ARM 17.24.640 | Provides that discharge from sedimentation ponds, impoundments, and diversions shall be controlled by vegetation, energy dissipaters, riprap channels, and other measures, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance. | Relevant and Appropriate |
| | ARM 17.24.641 | Sets methods for preventing drainage from acid-and toxic-forming spoils into ground and surface waters. | Relevant and Appropriate |
| | ARM 17.24.642 | Prohibits permanent impoundments with certain exceptions, and sets standards for temporary and permanent impoundments. | Relevant and Appropriate |
| | ARM 17.24.643-646 | Provides for groundwater and groundwater recharge protection, and surface and groundwater monitoring. | Relevant and Appropriate |
| | ARM 17.24.649 | Prohibits the discharge, diversion, or infiltration of surface and groundwater into existing underground mine workings. | Relevant and Appropriate |
| Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations | ARM 17.24.701-702 | Requirements for stockpiling soil. | Relevant and Appropriate |
| | ARM 17.24.703 | Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and post-mining land use. | Relevant and Appropriate |

**TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)**

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued) | ARM 17.24.711 | Requires a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area affected and capable of meeting the criteria set forth in 82-4-233, MCA shall be established on all areas of land affected except water areas and surface areas of roads. | Relevant and Appropriate |
| | ARM 17.24.713 | Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after top soil placement. | Relevant and Appropriate |
| | ARM 17.24.714 | According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established. | Relevant and Appropriate |
| | ARM 17.24.716 | Establishes the required method of revegetation and provides that introduced species may be substituted for native species as part of an approved plan. | Relevant and Appropriate |
| | ARM 17.24. 717 | Whenever tree species are necessary, trees adapted for local site conditions and climate shall be used. | Relevant and Appropriate |
| | ARM 17.24.718 | Soil amendments must be used as necessary to aid in the establishment of permanent vegetation; irrigation, management, fencing, or other measures may also be used after review and approval by the department. | Relevant and Appropriate |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued) | ARM 17.24.719 | Livestock grazing on reclaimed land is prohibited until revegetation is established and can sustain managed grazing. | Relevant and Appropriate |
| | ARM 17.24.721 | Section specifies that rills and gullies greater than 9 inches which form on the reclaimed area must be filled, graded or otherwise stabilized and the area reseeded or replanted. | Relevant and Appropriate |
| | ARM 17.24.723 | Monitoring of vegetation, soils and wildlife. | Relevant and Appropriate |
| | ARM 17.24.724 | Success of revegetation shall be measured on the basis of unmined reference areas. | Relevant and Appropriate |
| | ARM 17.24.726 | Sets means of measuring productivity. | Relevant and Appropriate |
| | ARM 17.24.728 | Sets requirements for composition of vegetation. | Relevant and Appropriate |
| | ARM 17.24.730 and 731 | Revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area. If toxicity to plants or animals is suspected, comparative chemical analysis may be required | Relevant and Appropriate |
| | ARM 17.24.733 | Sets requirements and measurement standards for trees, shrubs, and half-shrubs. | Relevant and Appropriate |

## TABLE 4-2. SUMMARY OF PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (CONTINUED)

| Standard, Requirement Criteria Or Limitation | Citation | Description | ARAR Status |
|---|---|---|---|
| Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued) | ARM 17.24.751 | Required site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened and endangered species identified at the site. | Relevant and Appropriate |
| | ARM 17.24.761 | Section requires fugitive dust control measures for site preparation and reclamation operations. | Relevant and Appropriate |

# 5.0 RISK ASSESSMENT

Human and environmental health threats associated with exposure to mine waste characterized during the site characterization of the Buckeye Mine areas have been evaluated through a risk assessment process. The risks were evaluated in regards to site-specific chemical concentrations and applicable exposure pathways. This assessment follows risk assessment procedures for abandoned mine sites as developed by the DEQ-MWCB.

## 5.1 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment performed for the Buckeye Mine areas generally follows the Federal Remedial Investigation/Feasibility Study process for CERCLA (Superfund) sites (EPA, 1988). The baseline human health risk assessment examines the effects of taking no action at the site. This abbreviated assessment involves two steps: hazard identification and risk characterization. These tasks are accomplished by evaluating available data and selecting contaminants of concern (CoCs), and then characterizing overall risk by comparing the concentrations of CoCs in various media to previously derived cleanup goals. These previously derived cleanup goals include a risk assessment for recreational use at abandoned mine sites completed for the DEQ-MWCB (Tetra Tech, 1996) and the EPA Region III risk-based concentration table (Smith, 1996).

### 5.1.1 Hazard Identification

The objective of hazard identification is to identify the CoCs at the site that pose the greatest potential human health risk. Standard EPA criteria for this selection include: (1) those contaminants that are associated with and present at the site; (2) contaminants with average concentrations at least three times above background levels; (3) contaminants with at least 20% of the measured concentrations above the detection limit; and (4) contaminants with acceptable quality assurance/quality control results applied to the data.

Contaminants typically associated with mine and mill wastes include heavy metals and cyanide. Samples of mill tailings, waste rock, and soil collected from the Buckeye Mine project were laboratory analyzed for total cyanide and the following thirteen metal and non-metal elements: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver and zinc. These analyses were supplemented by screening for a multi-element suite using a portable XRF analyzer. Stream sediments were laboratory analyzed for the same suite of analytes. Surface water samples used in the risk assessment were laboratory analyzed for thirteen elements as above and calcium and magnesium for use in hardness determination.

The Buckeye Mine project area includes a number of waste sources. Therefore, the site was divided into five subareas/waste source groups as presented in Table 5-1, and a risk assessment was completed on the waste sources in each group.

**TABLE 5-1. BUCKEYE MINE SITE SUBAREAS AND WASTE SOURCE GROUPS**

| Project Subarea | Waste Source Group |
|---|---|
| Buckeye Mine Tailings Subarea 1 | TP-1, TP-2, TP-3 |
| Buckeye Mine Tailings Subarea 2 | TP-4 and TP-5 |
| Buckeye Mine Waste Rock Subarea 1 | WR-1, WR-2, WR-3, WR-4 and Gossan Area |
| Buckeye Mine Waste Rock Subarea 2 | WR-5 |
| Brandon Mill Waste Area | BM |

The average concentration and multiplier above background for the elements analyzed in each waste source are shown in Table 5-2. Total cyanide was not detected in the waste sources at a concentration above the method detection limit of 0.5 mg/Kg.

The CoC's for each group were evaluated based on the criteria listed above and are shown in Table 5-3. Total cyanide is not expected to be detected in significant concentrations in background soil samples. Cyanide was not detected in any of the waste sources and is therefore not a CoC.

CoCs for surface water are selected based on exceedances of human health or Federal acute or chronic aquatic water standards. The Mill Creek surface water chemistry results collected during site characterization represent low flow conditions as they were collected after the snowmelt runoff and not during a stormwater runoff event. The surface water results indicate that Ag, As, Ba, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Sb and Zn were not detected in any of the surface water samples collected from Mill Creek. Iron (Fe) was detected in concentrations ranging from 70 µg/L to 80 µg/L. For low flow conditions, the data indicate that there is very little impact to the surface water quality and no exceedance of Federal or Montana surface water quality standards in Mill Creek near the site. However, field observations indicate that during snowmelt and/or stormwater runoff events, tailings and waste rock sediment are being eroded into Mill Creek from TP-4 and WR-5, respectively. For the purpose of risk assessment, one half of the method detection limit was used for non-detect analytes to provide a conservative evaluation of potential risks.

### 5.1.2 Exposure Scenarios

The following section presents the exposure assessment conducted for the Buckeye Mine site. The exposure assessment identifies the potentially exposed population(s) and exposure pathways and estimates exposure point concentrations and contaminant intakes. The previously derived risk-based cleanup goals were calculated using two exposure scenarios: a residential use scenario (Smith, 1996) and a recreational use scenario (Tetra Tech, 1996).

The residential use risk-based concentrations involve residential occupation of the contaminated land with the maximum level of exposure occurring for a child 0-6 years old (soil ingestion route). The resultant risk-based concentrations were derived for this worst-case residential exposure scenario by EPA Region III (Smith, 1996). The soil ingestion, dust inhalation exposure routes and drinking water ingestion exposure were based on the soil and water concentrations presented in Table 5-4.

**Table 5-2. MEAN ELEMENT CONCENTRATIONS IN PROJECT SUBAREAS AND WASTE SOURCE GROUPS AND MULTIPLIER ABOVE BACKGROUND CONCENTRATIONS**

| Sample ID | Ag (mg/Kg) | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) | CN (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Buckeye Mine Tailings Subarea 1 (TP-1, TP-2 and TP-3)** | | | | | | | | | | | | | | |
| Tailings | 10.6 | 105.7 | 127.0 | 4.2 | 21.0 | 264.2 | 25008.3 | ND | 584.1 | 22.7 | 1027.9 | 3.4 | 698.4 | ND |
| | 4.25 x | 11.74 x | 0.83 x | 8.47 x | 0.63 x | 7.68 x | 1.64 x | | 1.19 x | 1.00 x | 27.41 x | 1.36 x | 8.86 x | |
| **Buckeye Mine Tailings Subarea 2 (TP-4 and TP-5)** | | | | | | | | | | | | | | |
| Tailings | 24.9 | 193.7 | 58.4 | 30.6 | 17.0 | 688.3 | 27416.7 | 1.8 | 610.1 | 20.6 | 3073.4 | 16.1 | 4755.0 | ND |
| | 9.96 x | 21.52 x | 0.38 x | 61.20 x | 0.51 x | 20.01 x | 1.80 x | 3.53 x | 1.24 x | 0.91 x | 81.96 x | 6.42 x | 60.34 x | |
| **Buckeye Mine Waste Rock Subarea 1 (WR-1, WR-2, WR-3, WR-4 and Gossan Area)** | | | | | | | | | | | | | | |
| Waste Rock | 26.7 | 201.1 | 89.5 | 9.1 | 30.2 | 260.0 | 41125.0 | 1.4 | 679.3 | 33.5 | 5416.8 | 41.2 | 1787.5 | NA |
| | 10.66 x | 22.34 x | 0.59 x | 18.20 x | 0.91 x | 7.56 x | 2.70 x | 2.80 x | 1.38 x | 1.47 x | 144.45 x | 16.46 x | 22.68 x | |
| **Buckeye Mine Waste Rock Subarea 2 (WR-5)** | | | | | | | | | | | | | | |
| Waste Rock | 85.8 | 222.5 | 23.6 | 12.2 | 4.7 | 1024.5 | 48450.0 | 3.9 | 178.9 | 6.9 | 10375.0 | 34.2 | 2233.0 | NA |
| | 34.32 x | 24.72 x | 0.16 x | 24.40 x | 0.14 x | 29.78 x | 3.18 x | 7.80 x | 0.36 x | 0.30 x | 276.67 x | 13.68 x | 28.34 x | |
| **Brandon Mill Waste Area (BM)** | | | | | | | | | | | | | | |
| Waste | 108.5 | 353.3 | 99.3 | 10.6 | 21.4 | 742.5 | 51900.0 | 1.48 | 168.7 | 16.1 | 18435.0 | 18.1 | 2045.0 | ND |
| | 43.40 x | 39.26 x | 0.65 x | 21.20 x | 0.65 x | 21.58 x | 3.41 x | 2.96 x | 0.34 x | 0.71 x | 491.60 x | 7.24 x | 25.95 x | |
| **Mean Background Soil** | | | | | | | | | | | | | | |
| | 2.5 [a] | 9.0 | 152.2 | 0.5 [a] | 33.1 | 34.4 | 15240.0 | 0.5 [a] | 492.6 | 22.7 | 37.5 | 2.5 [a] | 78.8 | NA |

x *multiplier above mean background (x times greater than the mean)*

[a] *concentration less than lower detection limit; one half of lower detection used for calculation*

*NA not analyzed*

*ND concentration less than lower detection limit*

**TABLE 5-3. CONTAMINANTS OF CONCERN BY PROJECT SUBAREA AND WASTE TYPE**

| Project Subarea and Waste Source | CoCs |
|---|---|
| Buckeye Mine Tailings Subarea 1 | Ag, As, Cd, Cu, Pb, Zn |
| Buckeye Mine Tailings Subarea 2 | Ag, As, Cd, Cu, Hg, Pb, Sb, Zn |
| Buckeye Mine Waste Rock Subarea 1 | Ag, As, Cd, Cu, Pb, Sb, Zn |
| Buckeye Mine Waste Rock Subarea 2 | Ag, As, Cd, Cu, Fe, Hg, Pb, Sb, Zn |
| Brandon Mill Waste Area | Ag, As, Cd, Cu, Fe, Pb, Sb, Zn |

**TABLE 5-4. SOIL AND WATER CONCENTRATIONS USED TO EVALUATE RESIDENTIAL AND RECREATIONAL EXPOSURES**

| Project Subarea | Soil Ingestion and Dust Inhalation | Drinking Water Ingestion |
|---|---|---|
| Buckeye Mine Tailings Subarea 1 | Average concentrations observed in the near surface (0 to <5 feet) TP-1, TP-2 and TP-3 tailings areas from samples collected by Olympus in 2004. | Maximum concentrations from residential well water samples GW1 and GW2 and concentrations from surface water sample SW2 collected immediately downstream of the site by Olympus in 2004. |
| Buckeye Mine Tailings Subarea 2 | Average concentrations observed in the near surface (0 to <5 feet) TP-4 and TP-5 tailings areas from samples collected by Olympus in 2004. | Maximum concentrations from residential well water samples GW1 and GW2 and concentrations from surface water sample SW2 collected immediately downstream of the site by Olympus in 2004. |
| Buckeye Mine Waste Rock Subarea 1 | Average of near surface WR-1, WR-2, WR-3, and WR-4 waste rock samples collected by Olympus from test pits in 2004. Sample depths ranged from 0 to <2 feet. | Maximum concentrations from residential well water samples GW1 and GW2 and concentrations from surface water sample SW2 collected immediately downstream of the site by Olympus in 2004. |
| Buckeye Mine Waste Rock Subarea | Average of near surface WR-5 waste rock samples collected by Olympus from test pits in 2004. Sample depths ranged from 0 to <2 feet. | Maximum concentrations from residential well water samples GW1 and GW2 and concentrations from surface water sample SW2 collected immediately downstream of the site by Olympus in 2004. |
| Brandon Mill Waste Area | Average of near surface BM impacted soil samples collected by Olympus from test pits in 2004. Sample depths ranged from 0 to <2 feet. | Maximum concentrations from residential well water samples GW1 and GW2 and concentrations from surface water sample SW2 collected immediately downstream of the site by Olympus in 2004. |

The waste sources in the Buckeye Mine project are primarily located on patented mining claims, however, there is public and private land adjoining the mining claims. It should be noted that the access to the waste sources is to some extent restricted with fencing, gates and signs of no trespassing. Current human exposure to site-related contaminants is primarily related to recreational activities proceeding on and near the site.

The DEQ-MWCB has provided a measure of the health risks to recreational populations exposed to mine wastes in a report titled "Risk-based Cleanup Guidelines for Abandoned Mine Sites" (Tetra Tech, 1996). The risk-based guidelines were developed using a risk assessment that assumed four types of recreation populations: fishermen, hunters, gold panners/rockhounds and ATV/motorcycle riders. Field observations suggest that each of these uses has the propensity to occur in the Buckeye Mine site. Therefore, the exposed populations used in developing the DEQ-MWCB risk-based guidelines appear to be applicable to exposures that could reasonably be expected within the Buckeye Mine site. The maximum risk calculated for the applicable recreational exposure scenarios was for: 1) an ATV/motorcycle rider (mill tailings only); or 2) a rockhound/gold panner (waste rock and surface water only), or 3) a downstream fisherman (fish consumption only). A moderate level of recreational use was assumed for this site based on observations made during collection of data in 1993 for the DEQ-MWCB Abandoned Inactive Mine Scoring System (AIMSS), field observations during site characterization in 2004, and the potential for unrestricted site access. The soil ingestion and dust inhalation exposure routes for the ATV/motorcycle rider assumed a surface concentration equal to the average of near surface tailings samples collected from the Buckeye Mine tailings piles. The soil ingestion and dust inhalation exposure routes for the rockhound/gold panner assumed a concentration equal to the average waste rock samples collected from the Buckeye Mine waste rock piles. The water ingestion route assumed the measured water concentrations for sample SW2 for all of the Buckeye Mine waste subareas.

### 5.1.3 Toxicity Assessment

The toxicity assessment examines the potential for CoCs to cause adverse effects in exposed individuals and provides an estimate of the dose-response relationship between the extent of exposure to a particular contaminant and adverse effects. Adverse effects include both carcinogenic and noncarcinogenic health effects in humans. Sources of toxicity data include EPA's Integrated Risk Information System (IRIS, EPA, 1995), Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, Health Effects Assessment Summary Tables (HEAST), and EPA criteria documents. Individual toxicity profiles for each CoC are not presented here, however, they are provided in the reference documents (Smith, 1996, Tetra Tech, 1996). The existing risk-based concentrations that were used to characterize risks from exposure to the CoCs for each exposure scenario are presented in Tables 5-5 and 5-6 for residential and recreational scenarios, respectively. The risk values correspond to a lifetime cancer risk of $1x10^{-6}$ (one in one million) or hazard quotients equal to 1.

### 5.1.4 Risk Characterization

#### 5.1.4.1 Residential Land Use Scenario

The residential exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations (RBCs) in Table 5-5. These data were used to calculate

**TABLE 5-5. RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR THE RESIDENTIAL SCENARIO**

| Contaminant of Concern | Residential Soil Ingestion (soil conc.) (mg/Kg) | Residential Dust Inhalation (soil conc.) (mg/Kg) | Residential Water Ingestion (ug/L) |
|---|---|---|---|
| Antimony | 31 | NA | 15 |
| Arsenic | 23 (Noncarc)<br>0.43 (Carc) | 380 | 11<br>0.045 (Carc) |
| Cadmium | 39 (Noncarc) | 920 (Noncarc)<br>920 (Carc) | 18 |
| Copper | 3,100 | NA | 1,500 |
| Iron | 23,000 | NA | 11,000 |
| Lead | 400* | NA | 15* |
| Mercury | 23 | 7 | 11 |
| Silver | 390 | NA | 180 |
| Zinc | 23,000 | NA | 11,000 |

*Notes: NA = Not available*
*Noncarc = Noncarcinogenic*
*Carc = Carcinogenic*
**Lead levels derived from EPA recommendations, not RBC table (Smith, 1996).*

**TABLE 5-6. RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR THE RECREATIONAL SCENARIO, MODERATE USE SCENARIO**

| Contaminant of Concern | Recreational Soil Ingestion/Inhalation Waste Rock (mg/Kg) | Recreational Soil Ingestion/Inhalation Tailings (mg/Kg) | Recreational Water Ingestion (ug/L) | Recreational Fish Ingestion (water conc.) (ug/L) |
|---|---|---|---|---|
| Antimony | 1,172 | 2,080 | 408 | 4,300 |
| Arsenic | 646 (Noncarc)<br>2.78 (Carc) | 1,138 (Noncarc)<br>4.34 (Carc) | 306 (Noncarc)<br>1.324 (Carc) | 73.4 (Noncarc)<br>0.316 (Carc) |
| Cadmium | 3,500 | 6,300 (Noncarc)<br>77.8 (Carc) | 512 | 133 |
| Copper | 108,400 | 193,200 | 37,800 | 1,992 |
| Iron | NA | NA | NA | NA |
| Lead | 4,400 | 7,840 | 440 | 330 |
| Mercury | 880 | 1,476 | 306 | 0.588 |
| Silver | NA | NA | NA | NA |
| Zinc | 880,000 | NA | 306,000 | 68,800 |

*Notes: Noncarc = Noncarcinogenic @ HQ=1*
*Carc = Carcinogenic @ Risk =1.0X10$^{-6}$*
*NA - No RBC available*

resultant human health noncarcinogenic Hazards Quotients (HQs) and carcinogenic risk values for each CoC. The results of the risk calculations for the residential land use scenario in the Buckeye Mine project subareas are summarized in Tables 5-7 through 5-11. HQ values exceed one for the residential land use scenario for the following CoCs at the following locations:

- arsenic (6.7826) and lead (4.8163) via soil ingestion at the Buckeye Mine Tailings Subarea 1;
- arsenic (8.6783) and lead (8.1350) via soil ingestion at the Buckeye Mine Tailings Subarea 2;

**Table 5-7. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Residential Land Use Scenario – Buckeye Mine Tailings Subarea 1**

| Contaminant of Concern | Soil Ingestion | Dust Inhalation | Water Ingestion | Total HQ by CoC |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Arsenic | 6.7826 | 0.4105 | 0.1364 | 7.3295 |
| Cadmium | 0.1256 | 0.0053 | 0.3889 | 0.5198 |
| Copper | 0.1668 | NC | 0.0133 | 0.1801 |
| Lead | 4.8163 | 0.0019 | 0.0667 | 4.8849 |
| Silver | 0.0514 | NC | 0.0139 | 0.0653 |
| Zinc | 0.0322 | NC | 0.1191 | 0.1513 |
| Total HQ | 11.9749 | 0.4177 | 0.7383 | 13.1309 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 3.63E-04 | 4.11E-07 | 3.33E-05 | 3.97E-04 |
| Cadmium | NC | 5.33E-09 | NC | 5.33E-09 |
| Total Risk | 3.63E-04 | 4.16E-07 | 3.33E-05 | 3.97E-04 |

*NC - Not Calculated because no RBC provided in Smith, 1996*

**Table 5-8. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Residential Land Use Scenario – Buckeye Mine Tailings Subarea 2**

| Contaminant of Concern | Soil Ingestion | Dust Inhalation | Water Ingestion | Total HQ by CoC |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 0.5742 | NC | 0.1667 | 0.7409 |
| Arsenic | 8.6783 | 0.5253 | 0.1364 | 9.3400 |
| Cadmium | 0.8846 | 0.0375 | 0.3889 | 1.3110 |
| Copper | 0.2424 | NC | 0.0133 | 0.2557 |
| Lead | 8.1350 | 0.0033 | 0.0667 | 8.2050 |
| Mercury | 0.0783 | 0.2571 | 0.0273 | 0.3627 |
| Silver | 0.0677 | NC | 0.0139 | 0.0816 |
| Zinc | 0.2310 | NC | 0.1191 | 0.3501 |
| Total HQ | 18.8915 | 0.8232 | 0.9323 | 20.6470 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 4.64E-04 | 5.25E-07 | 3.33E-05 | 4.98E-04 |
| Cadmium | NC | 3.75E-08 | NC | 3.75E-08 |
| Total Risk | 4.64E-04 | 5.63E-07 | 3.33E-05 | 4.98E-04 |

*NC - Not Calculated because no RBC provided in Smith, 1996*

**Table 5-9. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Residential Land Use Scenario – Buckeye Mine Waste Rock Subarea 1**

| Contaminant of Concern | Soil Ingestion | Dust Inhalation | Water Ingestion | Total HQ by CoC |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 1.3258 | NC | 0.1667 | 1.4925 |
| Arsenic | 8.7435 | 0.5292 | 0.1364 | 9.4091 |
| Cadmium | 0.2333 | 0.0099 | 0.3889 | 0.6321 |
| Copper | 0.0839 | NC | 0.0133 | 0.0972 |
| Lead | 13.5420 | 0.0054 | 0.0667 | 13.6141 |
| Silver | 0.0682 | NC | 0.0139 | 0.0821 |
| Zinc | 0.0777 | NC | 0.1191 | 0.1968 |
| Total HQ | 24.0744 | 0.5445 | 0.9050 | 25.5239 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 4.68E-04 | 5.29E-07 | 3.33E-05 | 5.02E-04 |
| Cadmium | NC | 9.89E-09 | NC | 9.89E-09 |
| Total Risk | 4.68E-04 | 5.39E-07 | 3.33E-05 | 5.02E-04 |

*NC - Not Calculated because no RBC provided in Smith, 1996*

**Table 5-10. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Residential Land Use Scenario – Buckeye Mine Waste Rock Subarea 2**

| Contaminant of Concern | Soil Ingestion | Dust Inhalation | Water Ingestion | Total HQ by CoC |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 1.1032 | NC | 0.1667 | 1.2699 |
| Arsenic | 9.6957 | 0.5868 | 0.1364 | 10.4189 |
| Cadmium | 0.3128 | 0.0133 | 0.3889 | 0.715 |
| Copper | 0.3306 | NC | 0.0133 | 0.3439 |
| Iron | 2.1065 | NC | 0.0182 | 2.1247 |
| Lead | 25.9375 | 0.0104 | 0.0667 | 26.0146 |
| Mercury | 0.1696 | 0.5571 | 0.0273 | 0.7540 |
| Silver | 0.2200 | NC | 0.0139 | 0.2339 |
| Zinc | 0.0971 | NC | 0.1191 | 0.2162 |
| Total HQ | 39.9730 | 1.1676 | 0.9505 | 42.0911 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 5.19E-04 | 5.87E-07 | 3.33E-05 | 5.53E-04 |
| Cadmium | NC | 1.33E-08 | NC | 1.33E-08 |
| Total Risk | 5.19E-04 | 6.00E-07 | 3.33E-05 | 5.53E-04 |

*NC - Not Calculated because no RBC provided in Smith, 1996*

**Table 5-11. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Residential Land Use Scenario – Buckeye Mine Brandon Mill Waste Area**

| Contaminant of Concern | Soil Ingestion | Dust Inhalation | Water Ingestion | Total HQ by CoC |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 0.5839 | NC | 0.1667 | 0.7506 |
| Arsenic | 15.3609 | 0.9297 | 0.1364 | 16.4270 |
| Cadmium | 0.2718 | 0.0115 | 0.3889 | 0.6722 |
| Copper | 0.2397 | NC | 0.0133 | 0.2530 |
| Iron | 2.2565 | NC | 0.0182 | 2.2747 |
| Lead | 46.0875 | 0.0184 | 0.0667 | 46.1726 |
| Silver | 0.2782 | NC | 0.0139 | 0.2921 |
| Zinc | 0.0889 | NC | 0.1191 | 0.2080 |
| Total HQ | 65.1674 | 0.9596 | 0.9232 | 67.0502 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 8.22E-04 | 9.30E-07 | 3.33E-05 | 8.56E-04 |
| Cadmium | NC | 1.15E-08 | NC | 1.15E-08 |
| Total Risk | 8.22E-04 | 9.41E-07 | 3.33E-05 | 8.56E-04 |

*NC - Not Calculated because no RBC provided in Smith, 1996*

- antimony (1.3258), arsenic (8.7435) and lead (13.5420) via soil ingestion at the Buckeye Mine Waste Rock Subarea 1;

- antimony (1.1032), arsenic (9.6957), iron (2.1065) and lead (25.9375) via soil ingestion at the Buckeye Mine Waste Rock Subarea 2; and

- arsenic (15.3609), iron (2.2565) and lead (46.0875) via soil ingestion at the Buckeye Mine Brandon Mill Waste Area.

HQ values greater than one indicate the potential for harmful effects by a CoC via the specified pathway. Arsenic and lead exceed the HQ values of 1 for soil ingestion at all of the project subareas evaluated for residential risk. In addition, antimony exceeds the HQ value of 1 at the Buckeye Mine Waste Rock Subarea 1 and Buckeye Mine Waste Rock Subarea 2. Iron exceeds the HQ value of 1 at the Buckeye Mine Waste Rock Subarea 2 and Buckeye Mine Brandon Mill Waste Area. There are no exceedances of noncarcinogenic hazard quotients for the dust inhalation or water ingestion pathways.

The lower part of Tables 5-7 through 5-11 presents carcinogenic risk. Only arsenic and cadmium have carcinogenic RBCs. Arsenic and cadmium are both CoCs in the Buckeye Mine site. The soil ingestion carcinogenic risks for arsenic in the tailings Subareas 1 and 2 are 3.63E-04 and 4.64E-04, respectively. The water ingestion carcinogenic risk is 3.33E-05 for both tailings Subarea 1 and 2. In the Buckeye Mine Waste Rock Subareas 1 and 2, the soil ingestion carcinogenic risks for arsenic are 4.68E-04 and 5.19E-04, respectively. The water ingestion carcinogenic risk is 3.33E-05 for both waste rock Subareas 1 and 2. The arsenic soil ingestion carcinogenic risk in the wastes in the Brandon Mill Waste Area is 8.22E-04 and the arsenic water ingestion risk is 3.33E-05. Cadmium is a CoC for all of the project subareas and the carcinogenic risk values range from 1.15E-08 to 3.75E-08. The EPA utilizes a 1.0E-06 value as a point of departure in assessing the need for contaminant cleanup at a particular site. The site values for arsenic exceed the EPA point of departure for soil and water ingestion and the cadmium values do not.

#### 5.1.4.2 Recreational Land Use Scenario

The recreational exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations in Table 5-6. These data were used to calculate resultant human health carcinogenic risk values and noncarcinogenic HQs for each CoC. The results of the risk calculations for the recreational land use scenario in the Buckeye Mine site are summarized in Tables 5-12 through 5-16.

Within the recreational land use scenario, only the CoC lead at the Buckeye Mine Waste Rock Subareas 1 and 2 exceeded an HQ value of 1 via soil ingestion/dust inhalation for rockhounds and gold panners. Lead exceeded an HQ value of 1 for soil ingestion/dust inhalation for ATV and motorcycle riders at the Buckeye Mine Brandon Mill Waste Area. No HQ values exceed 1 at the Buckeye Mine Tailings Subareas 1 or 2.

The lower part of Tables 5-12 through 5-16 presents carcinogenic risk. Only arsenic and cadmium have carcinogenic RBCs. Arsenic and cadmium are both CoCs in the Buckeye Mine site. The arsenic carcinogenic risks for soil ingestion/dust inhalation for ATV and motorcycle riders in tailings ranged from 3.59E-05 to 4.60E-05. The arsenic carcinogenic risks for water ingestion for rockhounds and gold panners in Mill Creek in the tailings Subareas 1 and 2 is

**Table 5-12. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Recreational Land Use Scenario - Buckeye Mine Tailings Subarea 1**

| Contaminant of Concern | Soil Ingestion/ Dust Inhalation for Rockhounds and Gold Panners in Waste Rock | Soil Ingestion/ Dust Inhalation for ATV and Motorcycle Riders in Tailings | Water Ingestion Rockhounds and Gold Panners in Mill Creek | Fisherman Fish Ingestion |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Arsenic | NWR | 0.1371 | 0.0049 | 0.0204 |
| Cadmium | NWR | 0.0008 | 0.0010 | 0.0038 |
| Copper | NWR | 0.0027 | 0.0001 | 0.0025 |
| Lead | NWR | 0.2457 | 0.0023 | 0.0030 |
| Silver | NWR | NC | NC | NC |
| Zinc | NWR | 0.0007 | 0.0000 | 0.0001 |
| Total HQ | NWR | 0.3870 | 0.0083 | 0.0298 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | NWR | 3.59E-05 | 1.13E-06 | 4.75E-06 |
| Cadmium | NWR | 6.30E-08 | NC | NC |
| Total Risk | NWR | 3.60E-05 | 1.13E-06 | 4.75E-06 |

*NC - Not Calculated because no RBC provided in Smith, 1996*
*Silver was not detected in surface water.*
*NWR - No waste rock present in this Subarea*

**Table 5-13. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Recreational Land Use Scenario - Buckeye Mine Tailings Subarea 2**

| Contaminant of Concern | Soil Ingestion/ Dust Inhalation for Rockhounds and Gold Panners in Waste Rock | Soil Ingestion/ Dust Inhalation for ATV and Motorcycle Riders in Tailings | Water Ingestion Rockhounds and Gold Panners in Mill Creek | Fisherman Fish Ingestion |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | NWR | 0.0086 | 0.0061 | 0.0006 |
| Arsenic | NWR | 0.1754 | 0.0049 | 0.0204 |
| Cadmium | NWR | 0.0055 | 0.0010 | 0.0038 |
| Copper | NWR | 0.0039 | 0.0001 | 0.0025 |
| Lead | NWR | 0.4151 | 0.0023 | 0.0030 |
| Mercury | NWR | 0.0012 | 0.0010 | 0.5102 |
| Silver | NWR | NC | NC | NC |
| Zinc | NWR | 0.0053 | 0.0000 | 0.0001 |
| Total HQ | NWR | 0.6150 | 0.0154 | 0.5406 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | NWR | 4.60E-05 | 1.13E-06 | 4.75E-06 |
| Cadmium | NWR | 4.43E-07 | NC | NC |
| Total Risk | NWR | 4.64E-05 | 1.13E-06 | 4.75E-06 |

*NC - Not Calculated because no RBC provided in Smith, 1996*
*Silver was not detected in surface water.*
*NWR - No waste rock present in this Subarea*

**Table 5-14. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Recreational Land Use Scenario - Buckeye Mine Waste Rock Subarea 1**

| Contaminant of Concern | Soil Ingestion/ Dust Inhalation for Rockhounds and Gold Panners in Waste Rock | Soil Ingestion/ Dust Inhalation for ATV and Motorcycle Riders in Tailings | Water Ingestion Rockhounds and Gold Panners in Mill Creek | Fisherman Fish Ingestion |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 0.0351 | NT | 0.0061 | 0.0006 |
| Arsenic | 0.3113 | NT | 0.0049 | 0.0204 |
| Cadmium | 0.0026 | NT | 0.0010 | 0.0038 |
| Copper | 0.0024 | NT | 0.0001 | 0.0025 |
| Lead | 1.2311 | NT | 0.0023 | 0.0030 |
| Silver | 0.0000 | NT | NC | NC |
| Zinc | 0.0020 | NT | 0.0000 | 0.0001 |
| Total HQ | 1.5845 | NT | 0.0144 | 0.0304 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 7.23E-05 | NT | 1.13E-06 | 4.75E-06 |
| Cadmium | NC | NT | NC | NC |
| Total Risk | 7.23E-05 | NT | 1.13E-06 | 4.75E-06 |

*NC - Not Calculated because no RBC provided in Smith, 1996*
*Silver was not detected in surface water.*
*NT - No tailings present in this Subarea*

**Table 5-15. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Recreational Land Use Scenario - Buckeye Mine Waste Rock Subarea 2**

| Contaminant of Concern | Soil Ingestion/ Dust Inhalation for Rockhounds and Gold Panners in Waste Rock | Soil Ingestion/ Dust Inhalation for ATV and Motorcycle Riders in Tailings | Water Ingestion Rockhounds and Gold Panners in Mill Creek | Fisherman Fish Ingestion |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | 0.0292 | NT | 0.0061 | 0.0006 |
| Arsenic | 0.3452 | NT | 0.0049 | 0.0204 |
| Cadmium | 0.0035 | NT | 0.0010 | 0.0038 |
| Copper | 0.0095 | NT | 0.0001 | 0.0025 |
| Iron | 0.0485 | NT | 0.0001 | 0.0001 |
| Lead | 2.3580 | NT | 0.0023 | 0.0030 |
| Mercury | 0.0044 | NT | 0.0010 | 0.5102 |
| Silver | 0.0001 | NT | NC | NC |
| Zinc | 0.0025 | NT | 0.0000 | 0.0001 |
| Total HQ | 2.8009 | NT | 0.0155 | 0.5407 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | 8.02E-05 | NT | 1.13E-06 | 4.75E-06 |
| Cadmium | NC | NT | NC | NC |
| Total Risk | 8.02E-05 | NT | 1.1E-06 | 4.75E-06 |

*NC - Not Calculated because no RBC provided in Smith, 1996*
*Silver was not detected in surface water.*
*NT - No tailings present in this Subarea*

**Table 5-16. Summary of Noncarcinogenic Hazard Quotients (HQs) and Carcinogenic Risk Values for the Recreational Land Use Scenario - Buckeye Mine Brandon Mill Waste Area**

| Contaminant of Concern | Soil Ingestion/ Dust Inhalation for Rockhounds and Gold Panners in Waste Rock | Soil Ingestion/ Dust Inhalation for ATV and Motorcycle Riders in Tailings | Water Ingestion Rockhounds and Gold Panners in Mill Creek | Fisherman Fish Ingestion |
|---|---|---|---|---|
| Noncarcinogenic HQ Summary | | | | |
| Antimony | NWR | 0.0087 | 0.0061 | 0.0006 |
| Arsenic | NWR | 0.3105 | 0.0049 | 0.0204 |
| Cadmium | NWR | 0.0017 | 0.0010 | 0.0038 |
| Copper | NWR | 0.0038 | 0.0001 | 0.0025 |
| Iron | NWR | 0.0519 | 0.0001 | 0.0001 |
| Lead | NWR | 2.3514 | 0.0023 | 0.0030 |
| Silver | NWR | 0.0001 | NC | NC |
| Zinc | NWR | 0.0020 | 0.0000 | 0.0001 |
| Total HQ | NWR | 2.7301 | 0.0145 | 0.0305 |
| | | | | |
| Carcinogenic Risk Summary | | | | |
| Arsenic | NWR | 8.14E-05 | 1.13E-06 | 4.75E-06 |
| Cadmium | NWR | 1.36E-07 | NC | NC |
| Total Risk | NWR | 8.15E-05 | 1.13E-06 | 4.75E-06 |

*NC - Not Calculated because no RBC provided in Smith, 1996*
*Silver was not detected in surface water.*
*NWR - No waste rock in this subarea*

1.13E-06. The calculated carcinogenic risk for arsenic for fisherman fish ingestion from Mill Creek is 4.75E-06.

In the waste rock project subareas, the carcinogenic arsenic soil ingestion/dust inhalation for rockhounds and gold panners ranges from 7.23E-05 to 8.02E-05. Water ingestion for rockhounds and gold panners in Mill Creek is 1.13E-06. The arsenic carcinogenic risk for fisherman fish ingestion from Mill Creek is 4.75E-06.

In the waste area of the Buckeye Mine Brandon Mill subarea, the carcinogenic arsenic soil ingestion/dust inhalation for ATV and motorcycle riders is 8.14E-05. Arsenic water ingestion for rockhounds and gold panners in Mill Creek is 1.13E-06. The arsenic carcinogenic risk for fisherman fish ingestion from Mill Creek is 4.75E-06.

The EPA utilizes a 1.0E-06 value as a point of departure in assessing the need for contaminant cleanup at a particular site. The site values for arsenic exceed the EPA point of departure value of 1.0E-06 for soil ingestion/dust inhalation for ATV and motorcycle riders in tailings and soil ingestion/dust inhalation for rockhounds and gold panners in waste rock. The carcinogenic risk for arsenic also exceeds 1.0E-06 for water ingestion and fisherman fish ingestion for all waste subareas.

Cadmium carcinogenic risk calculations were only completed for soil ingestion/dust inhalation for ATV and motorcycle riders in tailings. This pathway did not exceed the EPA point of departure value for assessing the need for carcinogenic cadmium contaminant cleanup.

## 5.2 ECOLOGICAL RISK ASSESSMENT

### 5.2.1 Introduction

The ecological risk assessment was performed for the Buckeye Mine site areas following Federal RI/FS guidance for CERCLA (Superfund) sites (EPA, 1988). The key guidance documents used were EPA's Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (EPA, 1989b), and Ecological Assessment of Hazardous Waste Sites (EPA, 1989c). The waste materials present at the site pose a potential risk not only to humans, but also to other species that come into contact with them. Due to the sparse and indirect nature of the ecologic risk data available for the site, this evaluation is intended as a screening-level ecological risk assessment and the results are of a qualitative nature.

The ecological risk assessment estimates the effects of taking no action at the site and involves four steps: 1) identification of contaminants and ecologic receptors of concern; 2) exposure assessment; 3) ecologic effects assessment; and 4) risk characterization. These four tasks are accomplished by evaluating available data and selecting contaminants, species and exposure routes of concern, estimating exposure point concentrations and intakes, assessing ecologic toxicity of the CoCs, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

Problems in the Buckeye Mine site area that could impact ecologic receptors include elevated concentrations of metals in waste materials on-site (mill tailings and waste rock piles) and elevated concentrations of metals in soils. The limited sampling of surface water and stream sediments downgradient from the site did not identify elevated concentrations of metals. The accessible waste materials may result in significant ecological effects; the objective of this ecological risk assessment is to estimate current and future effects of implementing the no-action alternative in the Buckeye Mine project area.

### 5.2.2 Contaminants of Concern

As in the human health risk assessment, contaminants that are significantly above background concentrations and are associated with the site are retained as CoCs. The CoCs for the different project subareas are presented in Table 5-3. These contaminants are characteristic of hardrock mining wastes and represent contamination reliably associated with site activities. However, several of these contaminants have no ecologic toxicity data with which to evaluate potential effects.

Three groups of ecologic receptors have been identified as potentially affected by site contamination. The first receptor group are those associated with Mill Creek and include fisheries, aquatic life and wetlands. These surface water receptors are evaluated using USEPA aquatic life criteria, which apply to aquatic organisms only; there are no criteria with which to evaluate wetlands.

The second group of receptors is terrestrial wildlife that may use this area as part of their summer range, including deer and elk. The possibility exists for use by wildlife, both for water and for consumption of evaporative salts that can form on the wastes. This poses a potential for contaminant accumulation and subsequent health effects in the wildlife populations that visit the site. The only terrestrial wildlife receptor evaluated was deer which probably represent the highest level of exposure to site contaminants; the effects to deer can be assumed to apply to other wildlife receptors.

The third group of receptors are native terrestrial plant communities, which are noticeably absent on some of the waste sources in the Buckeye Mine project areas. They are of concern because the absence of vegetation enhances erosion and exposure to the wastes by potential human and wildlife receptors.

### 5.2.3 Exposure Assessment

The three exposure scenarios can be semi-quantitatively assessed, however, only the deer ingestion of salts and water scenario involves the calculation of a dose. Both the surface water aquatic life and plant phytotoxicity can be compared directly to existing toxicity standards that apply to environmental media.

#### 5.2.3.1 Surface Water/Sediment - Aquatic Life Scenario

Ecologic exposures via this pathway are threefold: 1) direct exposure of aquatic organisms to surface water concentrations that exceed toxicity thresholds; 2) ingestion of aquatic species (e.g., insects) that have bioaccumulated contaminants to the extent that they are toxic to the predator (e.g., fish); and 3) exposure of aquatic organisms (e.g., fish embryos) to sediment pore water environments that are toxic due to elevated contaminant concentrations in the sediments. Sediment data used for this assessment were collected from Mill Creek during the site characterization in 2004. Water data were collected in Mill Creek. Selected water quality and sediment concentration data are presented in Tables 5-17 and 5-18.

#### 5.2.3.2 Deer Ingestion Scenario

Wildlife salt uptake data provided in "Elk of North America" ranges from 1 to 11 pounds in one month for a herd of 50 to 75 elk (USDA, 1995). Using a median exposure (non-conservative) approach, the average salt usage (6 pounds/month) was divided by the average herd size (63) for an average individual salt uptake of 0.0032 pounds/day, or 0.00144 Kilograms/day (Kg/day). This intake is modified by the uptake of an additional 50% (0.00072 Kg/day) of non-salt wastes associated with the evaporative salt deposits at the site and then divided in half to account for the lower body weight of deer with respect to elk, for a total uptake of 0.0011 Kg/day. The salts are assumed to have the same concentrations as the tailings, since they are solubilized and reprecipitated from minerals in the tailings. For the purpose of this calculation, the concentration data used were the same as those presented for soil and drinking water ingestion in Table 5-4. The average deer is assumed to weigh 150 pounds (68 Kg) and consume 10 liters of water per day. The data used to estimate the total deer intake dose is summarized in Table 5-19.

#### 5.2.3.3 Plant - Phytotoxicity Scenario

This scenario involves the limited ability of various plant species to grow in soil or wastes with high concentrations of site-related contaminants. Table 5-20 summarizes concentrations measured in waste materials in the Buckeye Mine project area during the 2004 characterization investigation.

### 5.2.4 Ecological Effects Assessment

The known effects of the site CoCs are available from several literature sources and are not repeated here. No site-specific toxicity tests were performed to support the ecologic risk assessment, either in-situ or at a laboratory. Only existing and proposed toxicity-based criteria and standards were used for this ecological effects assessment.

#### 5.2.4.1 Surface Water/Sediment - Aquatic Life Scenario

Freshwater acute (1-hour average) water quality criteria have been promulgated by the EPA for many of the CoCs. Several of these criteria are calculated as a function of water hardness and a few are numerical standards. The numerical water quality standards are presented in Table 5-21 and apply to all surface waters in the Buckeye Mine project area. Those criteria that are a function of hardness have been calculated for each project subarea and are presented in Table 5-22. The hardness and calculated acute criteria are dependent on the sample station and sample date. Because all of the elements of interest were below detection limit for the sampling event, one halve of the method detection limit was used to conservatively assess the risk.

The EPA has not finalized sediment quality criteria. Proposed sediment criteria for metals currently consist of the Effect Range - Low (ER-L) and Effect Range - Median (ER-M) values

**TABLE 5-17. MAXIMUM CONTAMINANT CONCENTRATIONS IN SURFACE WATER**

| | Concentration in Surface Water (µg/L) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Project Subarea** | **Ag** | **As** | **Cd** | **Cu** | **Fe** | **Hg** | **Pb** | **Sb** | **Zn** |
| Buckeye Mine Tailings Subarea 1 (SW2) | ND | ND | ND | ND | NC | NC | ND | NC | ND |
| Buckeye Mine Tailings Subarea 2 (SW2) | ND | ND | ND | ND | NC | ND | ND | ND | ND |
| Buckeye Mine Waste Rock Subarea 1 (SW2) | ND | ND | ND | ND | NC | NC | ND | ND | ND |
| Buckeye Mine Waste Rock Subarea 2 (SW2) | ND | ND | ND | ND | 80 | ND | ND | ND | ND |
| Buckeye Mine Brandon Mill Waste Area (SW2) | ND | ND | ND | ND | 80 | NC | ND | ND | ND |

*Notes: NC - Not a contaminant of concern in this project subarea*
*ND - below laboratory detection limits*

**TABLE 5-18. MAXIMUM CONTAMINANT CONCENTRATIONS IN STREAM SEDIMENT**

| | Concentration in Sediment (mg/Kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Project Subarea** | **Ag** | **As** | **Cd** | **Cu** | **Fe** | **Hg** | **Pb** | **Sb** | **Zn** |
| Buckeye Mine Tailings Subarea 1 (SE2) | ND | ND | ND | 14.5 | NC | NC | 8.9 | NC | 20 |
| Buckeye Mine Tailings Subarea 2 (SE2) | ND | ND | ND | 14.5 | NC | ND | 8.9 | ND | 20 |
| Buckeye Mine Waste Rock Subarea 1 (SE2) | ND | ND | ND | 14.5 | NC | NC | 8.9 | ND | 20 |
| Buckeye Mine Waste Rock Subarea 2 (SE2) | ND | ND | ND | 14.5 | 8,570 | ND | 8.9 | ND | 20 |
| Buckeye Mine Brandon Mill Waste Area (SE2) | ND | ND | ND | 14.5 | 8,570 | NC | 8.9 | ND | 20 |

*Notes: NC - Not a contaminant of concern in this project subarea*
*ND - below laboratory detection limits*

## TABLE 5-19. DEER INTAKE DOSE ESTIMATES

| | Water Ingestion (µg/L) | | | | |
|---|---|---|---|---|---|
| **Project Subarea** | **As** | **Cd** | **Cu** | **Pb** | **Zn** |
| Buckeye Mine Tailings Subarea 1 | 1.5 | 0.5 | 5 | 1 | 5 |
| Buckeye Mine Tailings Subarea 2 | 1.5 | 0.5 | 5 | 1 | 5 |
| Buckeye Mine Waste Rock Subarea 1 | 1.5 | 0.5 | 5 | 1 | 5 |
| Buckeye Mine Waste Rock Subarea 2 | 1.5 | 0.5 | 5 | 1 | 5 |
| Buckeye Mine Brandon Mill Waste Area | 1.5 | 0.5 | 5 | 1 | 5 |
| | **Wastes and Salts (mg/Kg)** | | | | |
| **Project Subarea** | **As** | **Cd** | **Cu** | **Pb** | **Zn** |
| Buckeye Mine Tailings Subarea 1 | 156 | 4.9 | 517.2 | 1,926.5 | 741.5 |
| Buckeye Mine Tailings Subarea 2 | 199.6 | 34.5 | 751.4 | 3,254 | 5,314 |
| Buckeye Mine Waste Rock Subarea 1 | 201.1 | 9.1 | 260 | 5,416.8 | 1,788 |
| Buckeye Mine Waste Rock Subarea 2 | 223 | 12.2 | 1,025 | 10,375 | 2,233 |
| Buckeye Mine Brandon Mill Waste Area | 353.3 | 10.6 | 743 | 18,435 | 2,045 |
| | **Total Intake Dose (mg/Kg)** | | | | |
| **Project Subarea** | **As** | **Cd** | **Cu** | **Pb** | **Zn** |
| Buckeye Mine Tailings Subarea 1 | 0.0027 | 0.0002 | 0.0090 | 0.0308 | 0.0125 |
| Buckeye Mine Tailings Subarea 2 | 0.0034 | 0.0006 | 0.0127 | 0.0519 | 0.0852 |
| Buckeye Mine Waste Rock Subarea 1 | 0.0034 | 0.0002 | 0.0049 | 0.0863 | 0.0292 |
| Buckeye Mine Waste Rock Subarea 2 | 0.0038 | 0.0003 | 0.0170 | 0.1651 | 0.0362 |
| Buckeye Mine Brandon Mill Waste Area | 0.0058 | 0.0002 | 0.0125 | 0.2933 | 0.0333 |

*Notes: No applicable standards exist for Ag, Fe, Hg or Sb*

**TABLE 5-20. CONTAMINANT CONCENTRATIONS IN NEAR SURFACE TAILINGS AND WASTE ROCK (MG/KG)**

| Project Subarea | Ag | As | Cd | Cu | Fe | Hg | Pb | Sb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | 20 | 156 | 4.9 | 517.2 | NC | NC | 1,926.5 | NC | 741.5 |
| Buckeye Mine Tailings Subarea 2 | 26.4 | 199.6 | 34.5 | 751.4 | NC | 1.8 | 3,254 | 17.8 | 5,314 |
| Buckeye Mine Waste Rock Subarea 1 | 26.6 | 201.1 | 9.1 | 260 | NC | NC | 5,416.8 | 41.1 | 1,788 |
| Buckeye Mine Waste Rock Subarea 2 | 85.8 | 223 | 12.2 | 1,025 | 48,450 | 3.9 | 10,375 | 34.2 | 2,233 |
| Buckeye Mine Brandon Mill Waste Area | 108.5 | 353.3 | 10.6 | 743 | 51,900 | NC | 18,435 | 18.1 | 2,045 |

*Notes: NC - Not a contaminant of concern in this project subarea*
*Concentrations in mg/Kg as defined in Table 5-4*

**TABLE 5-21. NUMERIC WATER QUALITY CRITERIA**

| Acute Criteria (ug/l) | As | Hg |
|---|---|---|
| All Project Subareas and Sample Stations | 340 | 1.7 |

**TABLE 5-22. HARDNESS-DEPENDENT WATER QUALITY CRITERIA**

| | Buckeye Mine all project Subareas | | | Buckeye Mine all project Subareas (1/2 method detection limit) | | |
|---|---|---|---|---|---|---|
| Contaminant of Concern | Water Conc (ug/l) | Hardness (mg/l) | Acute Criteria (ug/l) | Water Conc (ug/l) | Hardness (mg/l) | Acute Criteria (ug/l) |
| Cadmium | ND | 69 | | 0.5 | 69 | 1.5 |
| Copper | ND | 69 | | 5 | 69 | 9.9 |
| Lead | ND | 69 | | 1 | 69 | 50.9 |
| Silver | ND | 69 | | 2.5 | 69 | 2.1 |
| Zinc | ND | 69 | | 5 | 69 | 87.5 |

*Notes: ND - below laboratory detection limits*

generated from the pool of national fresh water and marine sediment toxicity information (Long and Morgan, 1991). The ER-M values are probably most appropriate to use for comparison to Mill Creek sediment data, and are presented in Table 5-23.

**TABLE 5-23. SEDIMENT QUALITY CRITERIA (PROPOSED)**

| Criteria (mg/kg) | As | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|
| Effect Range - Median (ER-M) | 85 | 9 | 390 | 110 | 270 |

### 5.2.4.2 Deer Ingestion Scenario

Adverse effects data for test animals were obtained from the Agency for Toxic Substances and Disease Registry toxicological profiles (ATSDR, 1991a, 1991b, 1991c) and from other literature sources (NAS, 1980; Maita et al, 1981). The data consist of dose (intake) levels that either cause no adverse effects (NOAELs) and/or the lowest dose observed to cause an adverse effect (LOAELs) in laboratory animals. The use of effects data for alternative species introduces an uncertainty factor to the assessment, however, effects data are not available for the species of concern (deer), so the effects data for laboratory animals (primarily rats) are adjusted only for increased body weight. These data are listed in Table 5-24.

**TABLE 5-24. TOXICOLOGICAL EFFECTS LEVELS FOUND IN THE LITERATURE**

| Dose (mg/Kg-day) | As | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|
| LOAEL - Rat | 6.4 | 0.014 | 90 | 0.005 | 571 |
| Reference: | ATSDR, 1991a, p30 | ATSDR, 1991b, p33 | NAS, 1980 | ATSDR, 1991c, p72 | Maita et al, 1981 |

*Note: LOAEL = Lowest observed adverse effect level.*

#### 5.2.4.3 Plant - Phytotoxicity Scenario

Information is available on the phytotoxicity for some of the CoCs (Kabata-Pendias and Pendias, 1992) and these are listed in Table 5-25. The U.S. Environmental Protection Agency (EPA) has published interim final ecological soil screening levels for some of the CoCs and others are pending (EPA, November 2003). The available EPA ecological soil screening levels for site CoCs are also presented in Table 5-25. EPA emphasizes that the soil screening levels are not appropriate to be used for cleanup levels but are values derived to avoid underestimating risk at sites. The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species.

**TABLE 5-25. SUMMARY OF SOIL CONCENTRATIONS USED FOR PHYTOTOXICITY ASSESSMENT (MG/KG)**

Concentration Range (mg/Kg, dry wt.)

| | As | Cd | Cu | Hg | Mn | Pb | Sb | Zn |
|---|---|---|---|---|---|---|---|---|
| 1 | 15-50 | 3-8 | 60-125 | 0.3-5 | 1,500-3,000 | 100-400 | 5-10 | 70-400 |
| 2 | | 32 | | | | 110 | | |

*Notes: 1 - Kabata-Pendias & Pendias, 1992*
*2 - EPA, 2003*

### 5.2.5 Risk Characterization

This section combines the ecologic exposure estimates and concentrations presented in Section 5.2.3 and the ecologic effects data presented in Section 5.2.4 to provide a screening level estimate of potential adverse ecologic impacts for the three scenarios evaluated. This was accomplished by generating ecologic impact quotients (EQs), analogous to the health HQs calculated for human exposures to noncarcinogens. CoC-specific EQs were generated by dividing the particular intake estimate or concentration by available ecological effect values or concentrations. As with HQs, if EQs are less than one, adverse ecologic impacts are not expected.

#### 5.2.5.1 Aquatic Life Surface Water Scenario

For this scenario, surface water concentration data are compared to acute aquatic life criteria. Limitations of this comparison are that the EPA water quality criteria are not species-specific toxicity levels. They represent toxicity to the most sensitive species, which may or may not be present in the Mill Creek drainage, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of the EQ calculations for this scenario are presented in Table 5-26.

The EQ values for each element in each project subarea are all below one with the exception of silver (1.1661). It is important to note, however, that the silver concentration in surface water was below the analytical method detection limit. EQ calculations are based on one half of the detection limit. The actual concentration of silver may be less than one half the detection limit, which results in an EQ value of less than one. Elements with EQ values greater than one half the potential for acute aquatic life impacts.

**TABLE 5-26. ECOLOGIC IMPACT QUOTIENTS FOR SURFACE WATER - ACUTE AQUATIC LIFE SCENARIO**

| Project Subarea | Ag | As | Cd | Cu | Hg | Pb | Zn |
|---|---|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | 1.1661 | 0.0044 | 0.3418 | 0.5066 | NC | 0.0196 | 0.0571 |
| Buckeye Mine Tailings Subarea 2 | 1.1661 | 0.0044 | 0.3418 | 0.5066 | 0.1765 | 0.0196 | 0.0571 |
| Buckeye Mine Waste Rock Subarea 1 | 1.1661 | 0.0044 | 0.3418 | 0.5066 | NC | 0.0196 | 0.0571 |
| Buckeye Mine Waste Rock Subarea 2 | 1.1661 | 0.0044 | 0.3418 | 0.5066 | 0.1765 | 0.0196 | 0.0571 |
| Buckeye Mine Brandon Mill Waste Area | 1.1661 | 0.0044 | 0.3418 | 0.5066 | NC | 0.0196 | 0.0571 |

*Notes: NC - Not a contaminant of concern in this project subarea*
*No acute aquatic life criteria exist for Fe or Sb*

#### 5.2.5.2 Aquatic Life Sediment Scenario

Stream sediment concentration data are compared to proposed sediment quality criteria using a similar method as for calculating surface water impacts. Limitations of this comparison include that these sediment quality criteria are preliminary and are also not species-specific. They represent sediment toxicity to the most sensitive species, which may or may not be present in the Mill Creek drainage area, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of these EQ calculations are presented in Table 5-27. As shown in Table 5-27, there are no applicable sediment criteria for antimony, iron, mercury and silver. For silver, mercury and antimony, the sediment concentrations were below the method detection limit for the sampling event. The EQs presented in Table 5-27 indicate that there is limited potential for aquatic life impacts (EQs greater than 1) based on sediment toxicity in Mill Creek in the vicinity of the Buckeye Mine waste sources.

**TABLE 5-2. ECOLOGIC IMPACT QUOTIENTS (EQS) FOR THE SEDIMENT - AQUATIC LIFE SCENARIO**

| Project Subarea | As | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | 0.0294 | 0.0556 | 0.0372 | 0.0809 | 0.0741 |
| Buckeye Mine Tailings Subarea 2 | 0.0294 | 0.0556 | 0.0372 | 0.0809 | 0.0741 |
| Buckeye Mine Waste Rock Subarea 1 | 0.0294 | 0.0556 | 0.0372 | 0.0809 | 0.0741 |
| Buckeye Mine Waste Rock Subarea 2 | 0.0294 | 0.0556 | 0.0372 | 0.0809 | 0.0741 |
| Buckeye Mine Brandon Mill Waste Area | 0.0294 | 0.0556 | 0.0372 | 0.0809 | 0.0741 |

*Notes: NC - not a contaminant of concern in this project subarea*
*ND - below laboratory detection limits*
*No applicable standards exist for Ag, Fe, Hg or Sb*

### 5.2.5.3 Deer Ingestion Scenario

Estimated deer ingestion doses were compared to the higher of the literature derived toxicological effect level (the LOAEL) and CoC-specific EQs were generated by dividing the intake estimates by the toxicological effect value. Again, the comparison is limited because of the use of effects data for alternate species, adjusted only for increased body weight and the species used for the toxicology studies may be more or less susceptible to the contaminant being studied than deer. The results of the EQ calculations for this scenario are presented in Table 5-28.

**TABLE 5-28. ECOLOGIC IMPACT QUOTIENTS (EQS) FOR THE DEER INGESTION SCENARIO - LOAEL**

| Project Subarea | As | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | 0.0004 | 0.0108 | 0.0001 | 6.1557 | 0.0000 |
| Buckeye Mine Tailings Subarea 2 | 0.0005 | 0.0444 | 0.0001 | 10.3771 | 0.0001 |
| Buckeye Mine Waste Rock Subarea 1 | 0.0005 | 0.0156 | 0.0001 | 17.2548 | 0.0001 |
| Buckeye Mine Waste Rock Subarea 2 | 0.0006 | 0.0191 | 0.0002 | 33.0219 | 0.0001 |
| Buckeye Mine Brandon Mill Waste Area | 0.0009 | 0.0173 | 0.0001 | 58.6527 | 0.0001 |

*Notes: LOAEL = Lowest observed adverse effect level.*
*NC - not a contaminant of concern in this project subarea*
*No applicable standards exist for Ag, Fe, Hg or Sb*

The EQ data presented in Table 5-26 indicate the potential for adverse ecologic impacts (EQ greater than 1) to deer due to uptake of lead from the waste salts in the tailings, waste rock and impacted soils in all of the project subareas in the Buckeye Mine site. The assumptions used to derive the uptake dose and the comparison to rat toxicity, may overestimate the actual average contaminant intake, but likely by less than an order of magnitude. It should be noted that there are no applicable standards for antimony, iron, mercury or silver.

### 5.2.5.4 Plant - Phytotoxicity Scenario

Source area average concentrations collected in the Buckeye Mine area are compared to high values of the range of plant phytotoxicity derived from the literature. Limitations of this comparison include that the phytotoxicity ranges are not species-specific and they represent toxicity to species which may or may not be present in the project area. Additionally, other physical characteristics of the waste materials may create microenvironments which limit growth and survival of terrestrial plants directly or in combination with substrate toxicity. Waste materials are likely to have poor water holding capacity, low organic content, limited nutrient, and may harden enough to resist root penetration. The results of the EQ calculations for this scenario are presented in Table 5-29

The EQs presented in Table 5-29 indicate the potential for adverse ecologic impacts to plant communities from arsenic, copper, lead and zinc in all of the project subareas in the Buckeye Mine site. Cadmium is a potential phytotoxic element for plants in all of the project subareas

**TABLE 5-29. ECOLOGIC IMPACT QUOTIENTS (EQS) FOR THE PLANT - PHYTOTOXICITY SCENARIO**

| Project Subarea | As | Cd | Cu | Hg | Mn | Pb | Sb | Zn |
|---|---|---|---|---|---|---|---|---|
| Buckeye Mine Tailings Subarea 1 | 3.1200 | 0.6125 | 4.1376 | NC | NC | 4.8163 | NC | 1.8538 |
| Buckeye Mine Tailings Subarea 2 | 3.9920 | 4.3125 | 6.0112 | 0.3600 | NC | 8.1350 | 1.7800 | 13.2850 |
| Buckeye Mine Waste Rock Subarea 1 | 4.0220 | 1.1375 | 2.0800 | NC | NC | 13.5420 | 4.1100 | 4.4700 |
| Buckeye Mine Waste Rock Subarea 2 | 4.4600 | 1.5250 | 8.2000 | 0.7800 | NC | 25.9375 | 3.4200 | 5.5825 |
| Buckeye Mine Brandon Mill Waste Area | 7.0660 | 1.3250 | 5.9440 | NC | NC | 46.0875 | 1.8100 | 5.1125 |

*Notes: NC - not a contaminant of concern in this project subarea*
*No applicable standards exist for Ag and Fe*

except for the Buckeye Mine Tailings Subarea 1. The non-conservative assumption of using the high end of the phytotoxicity range to derive the EQs probably underestimates the potential phytotoxic effect to the plant community.

### 5.2.6 Risk Characterization Summary

The calculated EQs can be used to assess whether ecologic receptors are exposed to potentially harmful doses of site-related contaminants via the four ecologic scenarios evaluated. The EQs for each of the four scenarios are presented in Table 5-30 to estimate a combined EQ for each scenario and each contaminant. The EQ values in the table are the maximum value for the respective scenario or CoC. The results of combining the ecologic scenarios are also summarized in Table 5-30.

The EQs shown in Table 5-30 indicate that the contaminants at the site constitute probable adverse ecologic effects via the deer ingestion and plant phytotoxicity exposure scenarios. The elevated surface water scenario ecologic quotient is driven by silver. The ecologic risk assessment for silver is conservative for this element was not detected above the method detection limit for the sample event. For the purpose of the risk calculation one half the detection limit was used.

The totals by CoC for arsenic, cadmium, copper, lead, silver and zinc resulted in EQ values greater than one in all of the project subareas. The total risk for silver is conservatively estimated based on the surface water ecologic hazard quotient issue discussed earlier. Mercury did not exceed EQ values greater than one, however, no applicable standards exist for antimony, iron, mercury or silver for evaluation of sediment, deer ingestion or plant phytotoxicity exposure scenarios. Therefore, the total EQ values for antimony, iron, mercury and silver will be underestimated.

**Table 5-30. Summary of Combined Ecologic Impact Quotients for the Buckeye Mine Site**

| | Surface Water | Sediment | Deer Ingestion | Plant Phytotoxicity | Total by CoC |
|---|---|---|---|---|---|
| **Buckeye Mine Tailings Subarea 1** | | | | | |
| Arsenic | 0.0044 | 0.0294 | 0.0004 | 3.1200 | 3.1542 |
| Cadmium | 0.3418 | 0.0556 | 0.0108 | 0.6125 | 1.0207 |
| Copper | 0.5066 | 0.0372 | 0.0001 | 4.1376 | 4.6815 |
| Lead | 0.0196 | 0.0809 | 6.1557 | 4.8163 | 11.0725 |
| Mercury | NC | NC | NC | NC | NC |
| Silver | 1.1661 | NS | NS | NS | 1.1661 |
| Zinc | 0.0571 | 0.0741 | 0.0000 | 1.8538 | 1.9850 |
| TOTAL | 2.0956 | 0.2772 | 6.1670 | 14.5402 | 23.0800 |
| **Buckeye Mine Tailings Subarea 2** | | | | | |
| Antimony | NS | NS | NS | 1.7800 | 1.7800 |
| Arsenic | 0.0044 | 0.0294 | 0.0005 | 3.9920 | 4.0263 |
| Cadmium | 0.3418 | 0.0556 | 0.0444 | 4.3125 | 4.7543 |
| Copper | 0.5066 | 0.0372 | 0.0001 | 6.0112 | 6.5551 |
| Lead | 0.0196 | 0.0809 | 10.3771 | 8.1350 | 18.6126 |
| Mercury | 0.1765 | NS | NS | 0.36 | 0.5365 |
| Silver | 1.1661 | NS | NS | NS | 1.1661 |
| Zinc | 0.0571 | 0.0741 | 0.0001 | 13.2850 | 13.4163 |
| TOTAL | 2.2721 | 0.2772 | 10.4222 | 37.8757 | 50.8472 |
| **Buckeye Mine Waste Rock Subarea 1** | | | | | |
| Antimony | NS | NS | NS | 4.1100 | 4.1100 |
| Arsenic | 0.0044 | 0.0294 | 0.0005 | 4.0220 | 4.0563 |
| Cadmium | 0.3418 | 0.0556 | 0.0156 | 1.1375 | 1.5505 |
| Copper | 0.5066 | 0.0372 | 0.0001 | 2.0800 | 2.6239 |
| Lead | 0.0196 | 0.0809 | 17.2548 | 13.5420 | 30.8973 |
| Mercury | NC | NC | NC | NC | NC |
| Silver | 1.1661 | NS | NS | NS | 1.1661 |
| Zinc | 0.0571 | 0.0741 | 0.0001 | 4.4700 | 4.6013 |
| TOTAL | 2.0956 | 0.2772 | 17.2711 | 29.3615 | 49.0054 |
| **Buckeye Mine Waste Rock Subarea 2** | | | | | |
| Antimony | NS | NS | NS | 3.4200 | 3.4200 |
| Arsenic | 0.0044 | 0.0294 | 0.0006 | 4.4600 | 4.4944 |
| Cadmium | 0.3418 | 0.0556 | 0.0191 | 1.5250 | 1.9415 |
| Copper | 0.5066 | 0.0372 | 0.0002 | 8.2000 | 8.744 |
| Lead | 0.0196 | 0.0809 | 33.0219 | 25.9375 | 59.0599 |
| Mercury | 0.1765 | NS | NS | 0.7800 | 0.1765 |
| Silver | 1.1661 | NS | NS | NS | 1.1661 |
| Zinc | 0.0571 | 0.0741 | 0.0001 | 5.5825 | 5.7138 |
| TOTAL | 2.2721 | 0.2772 | 33.0419 | 49.9050 | 84.7162 |
| **Buckeye Mine Brandon Mill Waste Area** | | | | | |
| Antimony | NS | NS | NS | 1.8100 | 1.8100 |
| Arsenic | 0.0044 | 0.0294 | 0.0009 | 7.0660 | 7.1007 |
| Cadmium | 0.3418 | 0.0556 | 0.0173 | 1.3250 | 1.7397 |
| Copper | 0.5066 | 0.0372 | 0.0001 | 5.9440 | 6.4879 |
| Lead | 0.0196 | 0.0809 | 58.6527 | 46.0875 | 104.8407 |
| Mercury | NC | NC | NC | NC | NC |
| Silver | 1.1661 | NS | NS | NS | 1.1661 |
| Zinc | 0.0571 | 0.0741 | 0.0001 | 5.1125 | 5.2438 |
| TOTAL | 2.0956 | 0.2772 | 58.6711 | 67.3450 | 128.3889 |

*NC - not a contaminant of concern in this project subarea*
*ND - below laboratory detection limits*
*NS - not calculated because no applicable standard exists*

# 6.0 RECLAMATION OBJECTIVES AND GOALS

The primary objective of reclamation in the Buckeye Mine project area is to protect human health and the environment in accordance with the guidelines set forth by the NCP. Specifically, the remedy selected must limit human and environmental exposure to the CoCs and reduce the mobility of those contaminants to reduce impacts to the local water resources.

## 6.1 ARAR-BASED RECLAMATION GOALS

### 6.1.1 Groundwater

The groundwater resources within the Buckeye Mine project are not currently used for a drinking water source, however, a potential future use of groundwater resources is for drinking water. Residential wells are located in close proximity to the southern portion of the Buckeye Mine site waste sources. These wells are reported to be in the shallow aquifer and are less than 50 feet in depth below ground surface. Therefore, the potential for shallow groundwater impacts is considered applicable to the site. The potential contaminants of concern at the site include: antimony, arsenic, cadmium, copper, iron, lead, mercury, silver and zinc.

ARAR-based reclamation goals are most often the maximum contaminant levels (MCLs), non-zero maximum contaminant level goals (MCLGs), or state drinking water standards, whichever are more stringent. Potential ARAR-based reclamation goals for the CoCs in the groundwater medium are presented in Table 6-1. Although groundwater is not being considered for remediation at this site, removing source material may affect groundwater metal concentrations.

**TABLE 6-1. ARAR-BASED RECLAMATION GOALS FOR GROUNDWATER**

| Chemical | Type | Concentration, ug/L |
|---|---|---|
| Antimony | MCL | 6 |
| Arsenic | HHS | 20 |
| Cadmium | MCL | 5 |
| Copper | PP | 1,300 |
| Iron | MCL | 300 |
| Lead | PP | 15 |
| Mercury | MCL | 2 |
| Silver | HA | 100 |
| Zinc | HA | 2,000 |

*Notes: HA - Health Advisory from EPA's "Drinking Water Standards and Health Advisories (EPA, 1996)*
*HHS - Human Health Standards for Groundwater Water (DEQ, 2002)*
*MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories (EPA, 1993)*
*PP - Priority Pollutant Criteria*

### 6.1.2 Surface Water

The results of the 2004 water quality investigation of Mill Creek in the area of the Buckeye Mine site by Olympus (DEQ-AMRB/Olympus, 2005) indicates that surface water resources near the site have not been impacted by mine/mill wastes at least during low flow conditions. There is, however, field evidence that indicates some mobilization of waste sources into Mill Creek most likely during stormwater/snowmelt runoff conditions. Reclamation of the site should address the exposure risks inherent with the waste sources and provide controls which will protect water resources downstream of this area. Thus, surface water quality standards are applicable to the site.

Aquatic Life Standards and Human Health Standards are common ARARs for the surface water medium. The more stringent of the two standards is identified as the ARAR-based reclamation goal. The potential contaminants of concern at the site are: antimony, arsenic, cadmium, copper, iron, lead, mercury, silver and zinc. The ARAR-based reclamation goals for surface water are presented in Table 6-2.

**TABLE 6-2. ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER**

| Chemical | Type | Concentration, ug/L |
|---|---|---|
| Antimony | HHS | 6 |
| Arsenic | HHS | 18 |
| Cadmium | CALS | 0.27 @ 100 mg/L hardness |
| Copper | CALS | 9.3 @ 100 mg/L hardness |
| Iron | MCL | 300 |
| Lead | CALS | 3.2 @ 100 mg/L hardness |
| Mercury | HHS | 0.05 |
| Silver | AALS* | 4.1* @ 100 mg/L hardness |
| Zinc | CALS | 119.8 @ 100 mg/L hardness |

*Notes: *There is no chronic aquatic life standard for silver, so the acute aquatic life standard, which is more stringent than the human health standard, is presented.*
*HHS - Human Health Standards for Surface Water (DEQ, 2002)*
*AALS - Freshwater Acute Aquatic Life Standards (DEQ, 2002)*
*CALS - Freshwater Chronic Aquatic Life Standards (DEQ, 2002)*

### 6.1.3 Soil

Chemical-specific ARARs are not available at this time for the soil medium.

## 6.2 RISK-BASED CLEANUP GOALS

Risk-based cleanup goals have been calculated for both the noncarcinogenic and carcinogenic estimates of human health risk in the Buckeye Mine project area. Risk-based cleanup goals are only presented for the CoCs for which the recreational risk assessment indicated an exceedance of the hazard quotient for noncarcinogens greater than one or an exceedance of the carcinogenic risk value greater than 1E-06, and the exposure pathway was considered complete. The concentrations were derived using the risk-based cleanup guidelines for abandoned mine sites developed by the DEQ-MWCB (Tetra Tech, 1996) and applying the exposure assumptions presented in Section 5.1.2. The risk-based goals for soil and water represent the lowest concentration for each CoC determined from the various exposure pathways considered and are presented in Table 6-3. The proposed cleanup goals attempt to reduce the risk of excess incidence of cancer to 1.0E-06 (EPA, 1990) and the noncarcinogenic health hazard quotient (HQ) to 1 (EPA, 1989a).

**TABLE 6-3. RISK-BASED CLEANUP GOALS FOR THE BUCKEYE MINE AREA ASSUMING MODERATE RECREATIONAL USE**

| Noncarcinogenic CoCs | Soil, mg/Kg | Water, ug/l |
|---|---|---|
| Lead | 4,400[ac] | |
| **Carcinogenic CoCs** | | |
| Arsenic | 2.78[a,d] | 0.316[b,d] |

*Notes:* [a]*Based on rockhound/gold panner soil ingestion/inhalation*
[b]*Based on fish ingestion*
[c]*Based on ATV/motorcycle rider soil ingestion/inhalation*
[d]*Based on carcinogenic risk @ 1.0E-06*

Although no residences are located within the boundary of the Buckeye Mine site area, at least three homes are located near the boundary of the southern portion of the site. Two homes are located not far to the east and west of the Brandon Mill and tailings pile TP-5 areas and one home is located just to the southwest of the tailings pile TP-4. Risk-based cleanup goals have been calculated for both the residential noncarcinogenic and carcinogenic estimates of human health risk in the Buckeye Mine project area. Risk-based cleanup goals are only presented for the CoCs for which the residential risk assessment indicated an exceedance of the hazard quotient for noncarcinogens greater than one or an exceedance of the carcinogenic risk value greater than 1E-06, and the exposure pathway was considered complete. The concentrations were derived using the risk-based cleanup guidelines for abandoned mine sites developed by the DEQ-MWCB (Tetra Tech, 1996) and applying the exposure assumptions presented in Section 5.1.2. The risk-based goals for soil and water represent the lowest concentration for each CoC determined from the various exposure pathways considered and are presented in Table 6-4. The proposed cleanup goals attempt to reduce the risk of excess incidence of cancer to 1.0E-06 (EPA, 1990) and the noncarcinogenic health hazard quotient (HQ) to 1 (EPA, 1989a).

**TABLE 6-4. RISK-BASED CLEANUP GOALS FOR THE BUCKEYE MINE AREA ASSUMING RESIDENTIAL USE**

| Noncarcinogenic CoCs | Soil, mg/Kg | Water, ug/l |
|---|---|---|
| Antimony | 31[a] | |
| Arsenic | 23[a] | |
| Iron | 23,000[a] | |
| Lead | 400 [a,c] | |
| **Carcinogenic CoCs** | | |
| Arsenic | 0.43[a,d] | 0.045[b,d] |

*Notes:* [a]*Based on residential soil ingestion*
[b]*Based on residential water ingestion*
[c]*Based on lead levels derived from EPA recommendations, not RBC table (Smith, 1996)*
[d]*Based on carcinogenic risk @ 1.0E-06*

# 7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES

To facilitate the evaluation of potentially applicable reclamation technologies, the solid media at the site can be divided into three general categories based on physical and/or chemical characteristics. These categories include:

- mill tailings;
- waste rock piles; and
- mine, millsite and tailings debris.

Treatment of the solid media is dependent on the concentration of metal contaminants in the media, as well as the physical characteristics of the media. The potential applicability of a technology is dependent on the interrelationship of reclamation technologies and the volume of material requiring treatment. A brief definition of each solid media category follows.

<u>Mill Tailings</u> - Mill tailings are generated from the milling and beneficiation of mined ore. Mill tailings are generally composed of fine to very fine-grained sand, silt and clay. Exposed mill tailings containing sulfide minerals, especially pyrite, may develop acid rock drainage (ARD). ARD is generated by the oxidation of sulfide minerals. This process may produce acid pH conditions and increased metal solubility. Mill tailings piles which have developed ARD conditions become source areas for metal, sulfate and total dissolved solids. These potential contaminants may be mobilized during precipitation (infiltration) and stormwater runoff. Mill tailings are located in five separate piles/impoundments at the Buckeye Mine site.

<u>Waste Rock Piles</u> - Waste rock piles consist of overburden, altered and/or unaltered wallrock/country rock, and below economic grade ore materials. The piles are generally located within a minimal haulage distance from the mine and contain non-mineralized and low-grade mineralized rock extracted from the mine. Waste rock piles generally contain run-of-mine muck and consist of poorly sorted rock materials ranging in size from boulders down to clay-size fractions. The nature and extent of the mineralization, climatic conditions, and natural buffering capacity of the rock pile and underlying soils determine the potential of the waste rock to generate ARD and impact water quality. Waste rock was encountered in five piles at the Buckeye Mine site.

<u>Mine, Millsite and Tailings Debris</u> - There are several old structures and debris and solid waste areas located within the Buckeye Mine site. The debris includes two small buildings, a loadout/ore chute structure, the remains of an agitator, a concrete slab and other miscellaneous wood and metal debris. The former Brandon Millsite contains a rock foundation and various wood and metal debris, including dilapidated mobile homes and steel drums. The debris may be impacted by potential contaminants at the site. The debris may require sorting to isolate contaminated material for special handling or decontamination.

## 7.1 IDENTIFICATION AND SCREENING OF RECLAMATION TECHNOLOGIES AND PROCESS OPTIONS

The purpose of identifying and screening technology types and processes is to eliminate those technologies and process options that are unfeasible. General response actions are refined into technology types and process options. The technology and process options are screened for reclaiming solid mine/mill waste consisting of mill tailings, waste rock and impacted soils in the

Buckeye Mine site. Although many remedial treatment technologies and process options have been evaluated by other workers for mine/mill solid waste, most of these are not considered feasible. These technologies involve a variety of techniques related to physical/chemical and thermal treatment processes. At the present time, most of these technologies would require extensive treatability studies, are cost prohibitive and thus not considered appropriate. Therefore, the screening process has only evaluated a limited number of treatment technologies. Table 7-1 summarizes the results of the screening process for developing reclamation alternatives for the Buckeye Mine site. The following discussion summarizes each of the reclamation technologies and process options identified.

### 7.1.1 No Action

The no action option would require no further reclamation or monitoring actions at the site. The no action response is generally used as a baseline against which other reclamation options can be compared.

### 7.1.2 Institutional Controls

Land use and access restrictions are potentially applicable institutional controls for the site. Land use restrictions would limit the possible future uses of the land by employing deed restrictions in the event of property sale. Access restrictions commonly utilize fencing to control access to the site area. Land use and access restrictions may be applicable in the case of no action, capping in place, on-site disposal or any option that would leave contaminated materials on site. Such restrictions would aid in controlling future activities that may compromise a reclamation action. Institutional controls involving access restrictions via fencing and/or land use controls do not achieve a clean-up goal but are considered options which may compliment other reclamation processes.

### 7.1.3 Engineering Controls

Engineering controls are used to reduce the mobility of contaminants by establishing barriers that prevent contaminant exposure and migration. Engineering controls typically include containment, capping, runon/runoff controls, revegetation and/or disposal. Engineering controls generally do not reduce the volume or toxicity of the hazardous materials.

#### 7.1.3.1 Containment

Containment technologies are used as source control measures. They are designed to eliminate direct contact and fugitive emissions from the contaminated materials. In addition, such controls are used to divert and minimize infiltration of surface water/precipitation that may contribute to erosion and/or leachate formation. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary from a simple soil cover to a multi-layered RCRA hazardous waste cap. Specific RCRA landfill closure design criteria are put forth in 40 CFR 264.310. RCRA-designed caps may not be appropriate in instances where there is low precipitation, the toxicity of the contaminated source is relatively low, the cap is considered temporary or the waste material is not leached by infiltrating water. Future land use upon closure may also influence cap design.

## TABLE 7-1. RECLAMATION TECHNOLOGY SCREENING SUMMARY

| General Response Actions | Remedial Technology | Process Option | Description | Screening Comment |
|---|---|---|---|---|
| **No Action** | None | Not Applicable | No Action | |
| **Institutional Controls** | Access Restrictions | Fencing | Security fences installed around contaminated areas to limit access | |
| | | Land Use Controls | Legal restrictions to control current and future land use | Potentially effective in conjunction with other technologies; Readily implementable |
| **Engineering Controls** | Containment | Wet Closure | Construct dam & flood tailings with water to limit oxidation/migration of contaminants by establishing anaerobic environment | Potentially effective if tailings consolidated and adequate water maintained during dry season; Implementable |
| | | Soil Cover | Apply soil and establish vegetation to cover contaminant source | Surface infiltration would be reduced by evapotranspiration, but not prevented; Readily implementable |
| | | Multi-layered RCRA Cap | Compacted clay layer covered with soil & vegetation in contaminated surface areas | Potentially effective for waste source surface isolation; surface infiltration would be significantly reduced; Readily implementable |
| | | Asphalt or Concrete Cover | Apply asphalt or concrete over areas of exposed tailings and waste rock | Limited feasibility due to cracking over long term |
| | Surface Controls | Consolidation | Combining tailings, waste rock and impacted soil into single area | Potentially effective if combined with other process options; involves moving solid mine waste to single area; Readily implementable |
| | | Grading | Level waste piles to reduce slopes for managing runoff, erosion & surface infiltration | Potentially effective if combined with other process options; Readily implementable |
| | | Revegetation | Add amendments to waste & seed to promote vegetation for controlling water infiltration & erosion | Potentially effective in arid climates if waste does not contain high concentrations of phytotoxic elements; Readily implementable |

## TABLE 7-1. RECLAMATION TECHNOLOGY SCREENING SUMMARY (CONTINUED)

| General Response Actions | Remedial Technology | Process Option | Description | Screening Comment |
|---|---|---|---|---|
| **Engineering Controls (continued)** | | Erosion Protection/ Runon Control | Erosion resistant materials, commercial fabrics placed on tailings; stormwater diversion structures to channel water away from tailings and waste rock | Potentially effective at reducing lateral contaminant migration; Readily implementable |
| | On-site Disposal | RCRA Landfill | Excavated solid mine/mill waste deposited on-site in RCRA landfill | Potentially effective; Readily implementable |
| | | Solid Waste Landfill | Excavated tailings & waste rock deposited in solid waste landfill | Potentially effective for non-hazardous materials or residues from other treatment options; Readily implementable. |
| | Off-site Disposal | Permitted Tailings Impoundment | Depositing tailings in permitted tailings facility | Potentially effective if facility can accept off-site tailings and is willing to do so |
| | | RCRA Landfill | Tailings & waste rock disposed of in RCRA-C permitted facility | Potentially effective; Readily implementable |
| | | Solid Waste Landfill | Non-hazardous mill solid wastes disposed of in non-RCRA C facility | Potentially effective for non-hazardous materials or residue from other treatment options; Readily implementable, but administratively questionable |
| **Excavation and Treatment** | Reprocessing | Milling and Smelting | Shipping tailings and waste rock to operating mill and/or smelter facility for extraction of metals | Potentially effective if economic concentrations of metals are present in wastes and an operating facility can accept off-site materials for processing and is willing to do so |
| | Fixation/ Stabilization | Cement/Pozzolan Additive | Tailings and waste rock are solidified with non-leachable cement or pozzolan | Extensive treatability testing and proper disposal of stabilized material would be required; Potentially implementable but cost prohibitive |
| **In-Situ Treatment** | Physical/Chemical Treatment | Stabilization | Tailings and waste rock treated in place when injected with stabilizing agent(s) | Extensive treatability testing required; Potentially implementable, but cost prohibitive |

Capping is an appropriate alternative when contaminated materials are to be left on site. The on-site capping option implementation is dependent on the relative toxicity of the contaminants and demonstrated impacts to human health and/or environment. Capping is also an option when excavation and disposal or treatment actions are cost prohibitive. Capping of mine/mill wastes is considered to be a standard construction practice employing accepted design methods and available equipment.

#### 7.1.3.2 Surface Controls

Surface controls are used to minimize contaminant migration. Surface controls alone may not be appropriate in areas where direct human contact is a primary concern. In these instances, surface controls are commonly integrated with containment to provide further protection. Surface control process options are directed at controlling water and wind impacts on contaminated materials. These options include consolidation, grading, revegetation, and erosion controls.

Consolidation involves grouping wastes of similar type in a common area for more efficient management or treatment. Consolidation is important in areas where multiple smaller waste sources are present and wastes are in sensitive areas (i.e. residential or floodplain). Grading is used to reshape and compact waste areas in order to reduce slopes, manage the runon/runoff and infiltration of surface water and control erosion. Depending on the site conditions, periodic maintenance may be necessary to control subsidence and erosion problems after closure.

Revegetation involves adding soil amendments to a limited depth in the waste in order to provide nutrients and organic materials to establish vegetation. In addition, neutralizing agents and/or additives to improve pH conditions and/or the water storage capacity of the waste may be appropriate. Revegetation is essential to controlling water and wind erosion processes and minimizing infiltration of water through plant evapotranspiration processes. Revegetation generally involves the selection of appropriate plant species, preparation of the seeding area, seeding and/or planting, mulching and/or chemical stabilization and finally fertilization. Depending on the success of revegetation, the site may require maintenance in order to establish a self-sustaining plant community.

Erosion protection includes using erosion resistant materials to control water and wind impact on the contaminated media surface. Processes include surface water diversions, application of mulch and natural or synthetic fabric mats, and riprap. The erosion resistant materials are strategically placed based on a knowledge of the drainage area characteristics, slopes, vegetation types and densities, soil texture, and precipitation data.

#### 7.3.1.3 On-Site Disposal

On-site disposal can be used as a permanent source control measure. On-site disposal may require solid waste or hazardous waste repository design or a modification of these designs. The design of the containment facility would depend on the toxicity and type of material requiring disposal. This reclamation technology involves placing the untreated or treated contaminated materials in an engineered repository located in the area of the site. Design specifications could range from a simple, unlined and covered impoundment to a double-lined and double-leachate collection system repository employing a RCRA-type cap. Contaminated media failing to meet Toxicity Characteristic Leaching Procedure (TCLP) criteria may require disposal in RCRA hazardous waste-type repository and could be subject to RCRA landfill closure performance standards. Solid wastes from the beneficiation of ores and minerals, however, are not considered hazardous wastes under RCRA regulations (CFR 261.4 (b) (7)).

#### 7.1.3.4 Off-Site Disposal

Off-site disposal involves excavating the contaminated materials and transporting them to an existing engineered repository permitted to accept such materials. Off-site disposal options may be applied to untreated or pre-treated contaminated media and would depend on the TCLP results for representative samples. Materials failing to meet TCLP criteria would require disposal in a RCRA-permitted facility. Less toxic materials could possibly be disposed of in a permitted solid waste or sanitary landfill. Solid wastes from the beneficiation of ores and minerals, however, are not considered hazardous wastes under RCRA regulations (CFR 261.4 (b) (7)).

Disposal of tailings and ore/waste rock materials in an existing permitted tailings or waste rock impoundment is considered not feasible because operating permits do not allow acceptance of off-site generated waste materials for disposal and, furthermore, mine/mill environmental managers have indicated that the environmental liability risk is not worth the endeavor. Likewise, potentially responsible parties do not want to undertake additional environmental liability by placing their waste materials at an operating mine facility that may be subject to future environmental liability.

### 7.1.4 Excavation and Treatment

Excavation and treatment processes involve the removal of the contaminated materials and subsequent treatment of them to reduce toxicity and/or volume. Treatment processes may involve a variety of techniques including chemical, physical or thermal methods. These methods are used to concentrate metal contaminants for additional treatment or recovery of economic constituents or to reduce the toxicity of hazardous constituents.

#### 7.1.4.1 Reprocessing

Reprocessing involves excavation and transportation of contaminated materials to an existing mill or smelter for processing and recovery of valuable metals. Applicability of this option is dependent on the concentration of economically viable elements and the ability and willingness of the facility to process the material and dispose of the waste. Reprocessing of mine/mill wastes from outside sources is not commonly practiced due to the low concentrations of metals in source materials, operating permits limiting processing of off-site materials, and Superfund liability.

#### 7.1.4.2 Fixation/Stabilization

Fixation/stabilization technologies employ treatment processes which chemically alter the contaminant to reduce its mobility or toxicity (fixation) or physically treat the contaminant by encapsulating with an inert material (stabilization). The technology involves mixing materials with binding agents under specific conditions to form a stable matrix. For inorganic contaminants, fixation/stabilization employs a reagent or combination of reagents to promote a chemical and/or physical change in order to reduce the mobility. Treatment processes commonly use lime, fly ash, or pozzolan/cement as additives.

### 7.1.5 In-Situ Treatment - Stabilization

In-situ treatment involves treating the contaminated materials in place with the objective of reducing mobility and toxicity of problem constituents. In-situ treatments provide less control than excavation and treatment options because they afford less efficient mixing of the additives. In-situ physical/chemical treatment technologies include stabilization, solidification and soil flushing. For the purpose of the Buckeye Mine site, only stabilization is discussed as a potential option. Stabilization has been used at some mining-related sites as a supporting reclamation technique. The process is similar to conventional stabilization in that one or more stabilizing agents are applied to the contaminated media by deep mixing techniques. At tailings sites, for example, some workers have used plowing tools which have been modified and are towed by dozers to achieve deeper mixing depths than afforded by conventional farm equipment.

## 7.2 IDENTIFICATION AND EVALUATION OF ALTERNATIVES

The purpose of the initial screening of alternatives is to identify those alternatives appropriate for a subsequent, detailed analysis. The initial screening also helps identify technology type, process options and specific data needs for detailed site characterization.

This section identifies potential reclamation alternatives from the reclamation technology types and associated process options that passed the initial screening effort presented in Section 7.1. Table 7-2 presents the preliminary reclamation alternatives for the Buckeye Mine site. These retained alternatives are further screened in this section on the basis of effectiveness, implementability, and relative costs. The objective of the preliminary screening is to better define the number of reclamation alternatives that will require detailed evaluation.

**TABLE 7-2. RECLAMATION ALTERNATIVES FOR THE BUCKEYE MINE SITE**

| | |
|---|---|
| Alternative 1: | No Action |
| Alternative 2: | Institutional Controls |
| Alternative 3: | Partial Consolidation/In-Place Containment |
| Alternative 4a: | On-site Disposal in a RCRA Subtitle C Repository |
| Alternative 4b: | On-site Disposal in a Constructed Modified RCRA Repository |
| Alternative 4c: | On-site Disposal in a Constructed Unlined Repository With A Multi-Layered Cap |
| Alternative 5: | Off-site Disposal in a Permitted Solid Waste Disposal Facility |
| Alternative 6: | Off-site Disposal in a RCRA-Permitted Hazardous Waste Disposal Facility |

The evaluation of effectiveness includes determining the ability of an alternative to manage the contaminated media sufficiently to achieve the reclamation goals and mitigate potential future exposure. The reclamation goals include overall protection of human health and the environment, compliance with ARARs, and short- and long-term effectiveness and/or performance related to reducing toxicity, mobility, and/or volume of contaminants. The effectiveness screening criteria considers the nature and extent of contamination and site-specific conditions such as geology, hydrology, climate and land use.

The implementability of each alternative is evaluated in light of the technical and administrative feasibility of constructing, operating and maintaining the reclamation alternative. Technical feasibility considerations include the applicability of the alternative to the waste source, availability of the required equipment and expertise to implement the alternative, and overall reliability of the alternative. Implementability also considers appropriate combinations of alternatives based on site-specific conditions. Administrative feasibility evaluates logistical and scheduling constraints.

Cost screening consists of developing conservative, order-of magnitude cost estimates for each reclamation alternative based on similar sets of assumptions, i.e. volume estimates. Costs have been developed by analyzing data available from screening and implementing reclamation alternatives at similar sites. Unit costs are based on assessments of materials handling and procurement, site conditions, administrative and engineering costs, and contingency and are based on present worth values. Total costs were derived by applying estimated unit costs to assumed volumes of material to be handled or quantity of work to be performed. Where possible, cost data incorporate actual operating costs and unit costs that have been realized during similar reclamation projects. The cost estimates are directed at reclamation alternatives that are focused on the tailings piles and waste rock.

Table 7-3 presents the estimated areas and volumes of tailings and waste rock that were used in the preliminary screening. These estimated areas and volumes are based on the MDSL/AMRB Hazardous Materials Inventory (MDSL/AMRB, 1993) completed for the Buckeye Mine (PA# 29-451) in August 1993. The preliminary assessment did not include TP-4, TP-5 or the Brandon Mill area so no chemistry or volume data were available for these waste sources during the preliminary screening. For planning purposes, it was assumed that the chemistry of TP-4, TP-5 and the Brandon Mill was similar to TP-1, TP-2 and TP-3. Olympus had estimated the volume of TP-4 at 2,900 cubic yards. At the time of the preliminary screening, TP-5 was considered part of the Brandon Mill area and had not been considered a separate entity. The Brandon Mill area (including TP-5) was not considered during the preliminary screening except for revegetation of the area; however, these waste sources are included in the detailed evaluation of reclamation alternatives in Section 8.

The reclamation alternatives were further screened in the following sections on the basis of effectiveness, implementability, and cost. A screening summary is presented after evaluating each alternative to identify alternatives that may be retained for further consideration and to offer rationale for exclusion of those alternatives that will no longer be considered.

### 7.2.1 Alternative 1: No Action

The no action alternative means that no reclamation is done at the site to control contaminant migration or to reduce toxicity or volume. This option would require no further reclamation investigation or monitoring action at the site.

**TABLE 7-3. WASTE SOURCE AREAS AND VOLUMES**

| Source ID | Area (SF) | Area (Acres) | Average Thickness (ft) | Volume (CY) |
|---|---|---|---|---|
| TP-1 | 6,750 | 0.155 | 10.0 | 2,500 |
| TP-2 | 11,700 | 0.269 | 6.46 | 2,800 |
| TP-3 | 3,780 | 0.087 | 12.86 | 1,800 |
| TP-4* | 26,040 | 0.598 | 3.01 | 2,900 |
| Total Tailings | 48,270 | 1.109 | -- | 10,000 |
| WR-1 | 432** | 0.010 | 5.00 | 80 |
| WR-2 | 54** | 0.001 | 5.00 | 10 |
| WR-3 | 324** | 0.007 | 5.00 | 60 |
| WR-4 | 16,200 | 0.372 | 5.33 | 3,200 |
| WR-5 | 8,100 | 0.186 | 3.33 | 1,000 |
| Total Waste Rock | 25,110 | 0.576 | -- | 4,350 |
| Total Waste | 73,380 | 1.685 | -- | 14,350 |

* Not reported in preliminary assessment. Area estimated from aerial photograph. Volume estimated based on 3' waste thickness

**Not reported in preliminary assessment. Estimated from volume based on 5' waste thickness

Effectiveness - Toxicity, mobility, and volume of contaminants would not be reduced under the no action alternative. Also, protection of human health and the environment would not be achieved under this alternative. The preliminary investigations conducted by DEQ-MWCB indicate that the Buckeye Mine site may be causing environmental impacts to the surface water below the site. The tailings and waste rock show little or no natural revegetation and tailings have potential to be eroded by wind and water. The no action alternative will not address potential surface water or groundwater impacts nor would it provide any controls on contaminant migration via direct contact or particulate emissions.

Implementability - Technical and administrative feasibility evaluation criteria do not apply to this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative.

Screening Summary - The no action response is generally used as a baseline against which other reclamation options can be compared. This alternative has been retained for further evaluation as suggested by the NCP.

### 7.2.2 Alternative 2: Institutional Controls

The institutional control alternative includes land use restrictions to prevent land development on or near the impacted areas and includes erecting fences to restrict access.

Effectiveness - This alternative is not practical considering the location of the tailings and waste rock piles. Controlling access would be very difficult because the site is in a relatively unpopulated area with limited access control. Although portions of the site are currently fenced, there are gates at the upper end of the site and at tailings pile TP-4. Tailings pile TP-4 is located adjacent to Mill Creek Road, which provides easy access. This could potentially result in vandalism to fences and unauthorized entry to the waste sources. It is not fully protective of human health and the environment if it is implemented as a stand alone option. No controls would be implemented for direct contact, stormwater runoff/infiltration, erosion or fugitive dust emissions. Toxicity, mobility, and volume of the contaminated media would not be reduced under this alternative.

Implementability - Institutional controls can be easily implemented. The alternative is applicable for controlling direct contact and restricting future inappropriate land development. Materials and labor are readily available. Reliability of this alternative is considered good for controlling direct contact as long as enforcement of institutional controls is maintained and deed restrictions are in place. Administrative feasibility is considered good due to the ease of implementation. This alternative, however, is not protective of the environmental resources nor is it fully protective of human health if implemented as a stand alone alternative.

Cost Screening - Table 7-4 presents the cost details associated with implementing this alternative. The total present worth cost for institutional controls is estimated at $177,271. Costs for institutional controls would be relatively low as compared to other reclamation alternatives except no action and Alternative 3 - In-Place Containment.

Screening Summary - Institutional controls will not be considered further as a stand-alone reclamation alternative, but may be used in conjunction with other selected reclamation alternatives.

### 7.2.3 Alternative 3: In-Place Containment

In-place containment technologies may involve establishing vegetation directly on the waste source or applying a cover over the waste source upon which the vegetation is established. Covers may range from a simple, single-layered soil cover to a complex, multi-layered cover consisting of various materials.

In most instances, cover soil must be added to tailings to establish vegetation. Texture, as opposed to phytotoxicity, is often a limiting factor when attempting to establish vegetation directly on tailings. Although most tailings are generally in the fine to very fine-grained particle size, an appreciable amount of fine silt and clay may be present. Tailings materials generally have unsuitable combinations of water holding capacity, bulk density, porosity, and infiltration properties for promoting plant growth.

Based on the absence of natural vegetation on the tailings piles, it is not likely that vegetation could be successfully established directly on TP-1, TP-2, TP-3 or TP-4. Erosion would be controlled by a grading plan and stormwater diversion controls. To accelerate the growth of a self-sustaining plant community, the tailings would probably require a soil cap prior to seeding and fertilization. Vegetation of covered waste materials would further stabilize the surface, decrease water infiltration by increasing evapotranspiration, and would minimize direct contact with contaminants. The difficulty with in-place containment of the tailings is managing the on-site water, including Mill Creek, which flows adjacent to TP-4.

Waste rock piles WR-1, WR-2, WR-3 and WR-4 are located on the hillside to the north of Mill Creek. In-place containment of these waste sources appears to be a viable alternative. All four waste rock piles are located out of the stream drainage, do not appear to be in the vicinity of springs and there is available space to grade, contour and cap the piles with cover soil.

**Table 7-4. Preliminary Cost Estimate for Alternative 2: Institutional Controls**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 8,832 | $8,832 | 8% |
| Logistics | | | | | |
| Site Clearing/Preparation | 1 | LS | 5,000 | $5,000 | |
| Perimeter Fencing | 5,020 | LF | 20 | $100,400 | |
| Deed Restriction | 1 | LS | 5,000 | $5,000 | |
| Subtotal | | | | $119,232 | |
| Construction Oversight | 15% | | | $17,885 | |
| Subtotal Capital Costs | | | | $137,117 | |
| Contingency | 10% | | | $13,712 | |
| TOTAL CAPITAL COSTS | | | | $150,828 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $150,828 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $177,271 | |

Given the above considerations, the reclamation strategy for Alternative 3 involves in-place containment of tailings piles TP-1, TP-2, TP-3 and TP-4, and in-place containment of the waste rock piles WR-1, WR-2, WR-3, WR-4 and WR-5. To protect waste sources that are adjacent to Mill Creek, the stream bank along tailings pile TP-4 would be lined with riprap and the toe of waste rock pile WR-5 would be pulled back away from Mill Creek. These sources were identified in the preliminary risk analysis and in subsequent field reconnaissance as the principal sources of concern (i.e., those sources which contribute the highest relative risks for groundwater and surface water degradation). As an alternative, an organic amendment could be incorporated into the graded waste rock piles and vegetation established directly on the piles if a suitable cover soil source(s) cannot be found. Runon/runoff controls would have to be designed as an integral part of the containment strategy.

Effectiveness - This alternative would reduce contaminant mobility at the site by removing or isolating some of the highest risk solid media contaminant sources from the immediate Mill Creek stream corridor via consolidating and capping. Establishing vegetation on the consolidated waste sources, with the application of cover soil, would reduce erosion and thereby limit contaminant mobility. Vegetation stabilizes the surface against water and wind erosion and reduces the potential for contaminant migration into groundwater. Vegetation would also aid in minimizing human and wildlife exposure to contaminants by direct contact and inhalation of dust. Careful selection of appropriate plant species that are metal tolerant, water tolerant and adapted to relatively high altitudes and relatively short growing seasons would be critical to this alternative. Although metal mobility would be minimized, full protection of groundwater would not be achieved and the toxicity and volume of the waste would not be reduced.

Implementability - The alternative is both technically and administratively feasible. Consolidation, grading and capping of wastes and establishment of vegetation are readily implementable using conventional construction techniques.

Cost Screening - The total present-worth cost for Alternative 3: Partial Consolidation/In-Place Containment is estimated at $140,281. Table 7-5 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital/construction costs.

Conceptual Design and Assumptions

No detailed surveys have been completed to estimate waste volumes or to complete accurate grading plans for the waste sources. It is assumed that each tailings pile is graded to provide positive drainage, but that there is no net increase in tailings area after grading.

Each waste rock pile will be graded in place to reduce the slopes and capped with cover soil. It is assumed that the grading will require moving one half of the volume of each waste rock pile to achieve the desired slopes and to remove WR-5 from the immediate stream corridor area. The grading is assumed to increase the plan area of each waste rock pile by 50 percent.

The following assumptions were used to estimate the costs associated with this alternative:

- Grading of the tailings will not increase the existing tailings area of 1.1 acres.

- Approximately 281 cubic yards of riprap will be used to protect the toe of the consolidated tailings pile TP-4 from erosion by Mill Creek.

**Table 7-5. Preliminary Cost Estimate for Alternative 3: In-Place Containment**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 6,666 | $6,666 | 8% |
| Logistics | | | | | |
| Access Road | 1200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 2.98 | Ac | 2,000 | $5,960 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| In-Place Containment | | | | | |
| Grade Tailings | 1.1 | Ac | 2,000 | $2,220 | |
| Grade Waste Rock Piles | 2,175 | CY | 4.00 | $8,700 | |
| Tailings Riprap Protection | 281 | CY | 25.00 | $7,025 | |
| Cover Soil | 4,775 | CY | 6.00 | $28,650 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 2,150 | LF | 2.00 | $4,300 | |
| Revegetation | | | | | |
| Seed/Fertilize | 3.26 | Ac | 1,000 | $3,260 | |
| Mulch | 3.26 | Ac | 1,000 | $3,260 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Subtotal | | | | $89,991 | |
| Construction Oversight | 15% | | | $13,499 | |
| Subtotal Capital Costs | | | | $103,490 | |
| Contingency | 10% | | | $10,349 | |
| TOTAL CAPITAL COSTS | | | | $113,839 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $113,839 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $140,281 | |

- Grading of the waste rock piles will require the excavation of one half of the volume of WR-1, WR-2, WR-3, WR-4 and WR-5, which is equivalent to 2,175 cy.

- Grading of each waste rock pile will increase the plan area by 50 percent.

- No reconstruction of Mill Creek will be required.

- A 1.5-feet-thick layer of cover soil (4,775 cubic yards) would overlay the graded tailings and waste rock piles. A suitable source of vegetative cover soil must be identified.

- Conventional plowing techniques would be adequate for preparing seed beds in the excavated source areas.

- The total surface area at the site requiring revegetation is approximately 3.26 acres (which includes the graded tailings areas, graded waste rock piles, Brandon Mill area and haul roads).

- The total length of required runon/runoff control diversion ditch in the waste consolidation area is approximately 2,150 lineal feet.

- A total of 5,020 lineal feet of 4-strand, barbed-wire fence will be constructed around the perimeter of the reclaimed areas.

<u>Screening Summary</u>

This alternative has been retained for detailed analysis since in-place containment may be a feasible and cost-effective remedy for the site since enough space appears to be available for grading the wastes and achieving an overall acceptable grading plan, and protecting the wastes from Mill Creek.

### 7.2.4 Alternative 4: On-Site Disposal in a Constructed Repository

Three separate reclamation scenarios have been evaluated under Alternative 4. The major differences between the three scenarios have to do with the design of the liner system which would underlay the encapsulated wastes. The three scenarios considered include: 1) construction of a repository which complies with all RCRA Subtitle C regulations for hazardous waste landfill closures (this scenario includes a double-liner system with integral primary and secondary leachate collection and removal systems) and a multi-layered cap; 2) construction of a modified RCRA repository which includes a single composite liner without a leachate collection and removal system, also with a multi-layered cap; and 3) construction of an unlined repository with a multi-layered cap. Design and construction costs associated with the three scenarios will vary according to the relative degree of protection provided by the liner system (i.e., the higher the relative degree of protection provided by the liner system, the higher the associated costs). Two of the above scenarios (scenarios 2 and 3) do not comply with EPA's Minimum Technology Guidance for hazardous waste landfill closures. However, the scenarios may still provide adequate environmental protection considering the chemical and physical characteristics of the Buckeye Mine wastes, in conjunction with the physical location of the proposed repository site and the area's generally semi-arid climate. Each repository design scenario will be individually evaluated (if the reclamation alternatives are analyzed in detail) using the Hydrologic Evaluation Landfill Performance (HELP) Model, developed by the EPA

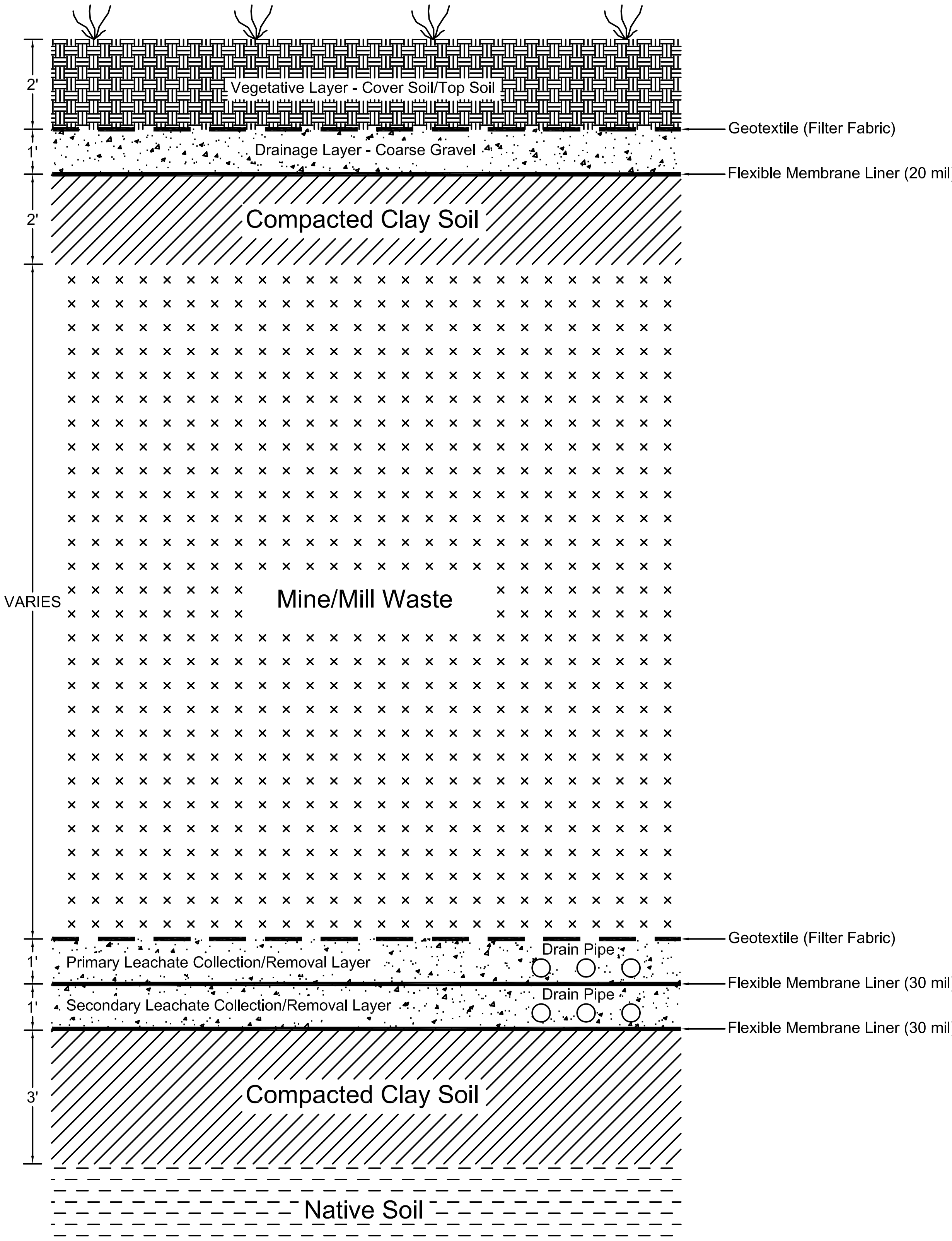
(1997) to determine the relative effectiveness of each design and ultimately conclude which design is most appropriate considering the anticipated expenditure (i.e., which design is most cost-effective).

The following conceptual design applies to Alternatives 4a, 4b and 4c. The sources to be disposed of in the repository include the four tailings piles and the five waste rock piles. A potential repository area is located north of waste rock pile WR4 and the former Buckeye mill site. To accommodate the wastes, the repository would require a footprint of approximately 130 feet by 330 feet (0.98 acres). The repository would be excavated into the subsurface to a depth of 3 feet with 4:1 side slopes and then extend 11 feet vertically above grade with 4:1 side slopes. The repository lining and capping configuration differ among the three alternatives. A considerable amount of heavy equipment/machinery would be necessary to efficiently implement these alternatives. To construct the repository and load out the waste material, as well as construct runon/runoff control structures, equipment requirements would include, but not be limited to, multiple bulldozers, front end loaders and excavators. Haul trucks or scrapers would also be required to transport and deposit the contaminated material in the constructed repository. The field procedure would involve improving the existing road from the repository area to WR-5 to a one lane haul road with turnouts to allow unobstructed access for heavy equipment. The number of loaders, haul trucks and/or scrapers would be maximized to the extent possible to reduce the overall time required to complete the project's construction phase.

Removal of the tailings from TP-4 would require the installation of a temporary bridge across Mill Creek to allow access to the repository area. There was formerly a bridge across Mill Creek in this area. As an alternate, the tailings from TP-4 could be hauled down Mill Creek road and up the gravel access road west of the site to the repository. After the repository construction, waste excavation, and waste placement are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level and contour the areas to match the surrounding terrain. The seed beds would be prepared using conventional agricultural plowing. Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas and the repository cap with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism. A runon/runoff control ditch would be constructed in the area of the repository to divert runoff away from the repository cap. Barbed-wire fencing would be placed around the excavated waste source areas to allow the establishment of vegetation without interference from livestock. A woven-wire fence would be constructed around the repository to limit access.

#### 7.2.4.1 Alternative 4a: On-Site Disposal in a Constructed RCRA Subtitle C Repository

The reclamation strategy for Alternative 4a involves removing all identified waste sources at the Buckeye Mine and disposing these wastes in a constructed repository which complies with all RCRA Subtitle C regulations for hazardous waste landfill closures (Figure 7-1). The repository would consist of a composite, double-lined leachate collection and removal system underlying the waste in conjunction with a composite, multi-layered, lined cap overlying the waste. It is assumed that the repository base can be excavated to a depth of three feet without interference from bedrock. The initial repository excavation will provide cover soil for capping the repository and reduce the overall height of the repository. If bedrock is encountered in the repository




**Olympus Technical Services, Inc.**

ALTERNATIVE 4A - ONSITE DISPOSAL IN A RCRA SUBTITLE C REPOSITORY

MONTANA DEQ/MINE WASTE CLEANUP BUREAU
BUCKEYE MINE RECLAMATION PROJECT
MADISON COUNTY, MONTANA

FIGURE 7-1

| Drawn: KSR | Checked: CRS | Date: 4/2005 | Job No: A1475 |
|---|---|---|---|
| Design: | Approved: | Scale: NONE | File: A1475-4A.dwg |

excavation, then additional cover soil will need to be recovered from elsewhere on site or from off site.

After the repository area has been excavated and the surface prepared, a bottom liner and leachate collection system would be installed. Once the waste sources are placed in the repository, a multi-layered cap would be constructed overlying the waste, and the repository cap would be revegetated. A runon/runoff control ditch would be constructed in the area of the repository to divert surface water away from the repository cap.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure disposal facility. Consequently, the surface water and wind erosion problems associated with the site are expected to be mitigated. Contaminant toxicity and volume would not be reduced, however, the waste would be rendered immobile in a structure and physical location protected from erosion problems. Long-term monitoring and control programs would be established to ensure continued effectiveness.

Implementability - This alternative is both technically and administratively feasible. The construction steps required are considered conventional construction practices. Key project components, such as the availability of equipment, materials, and construction expertise, are all present and would help ensure the timely implementation and successful execution of the proposed plan.

Cost Screening - The total present-worth cost for this alternative has been estimated at $566,208 which represents the reclamation of all the tailings and waste rock piles present at the Buckeye Mine. Table 7-6 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs. The cost estimate assumes that a geotextile cushion and geosynthetic clay liner (GCL) are used rather than compacted clay soil and geocomposite drainage layers are used for the leachate collection system rather than gravel and drain pipes.

The following assumptions were used to estimate the costs associated with this alternative:

- Requires approximately 1,200 feet of single-lane access road improvement with turnouts.
- The total volume of waste material to be excavated and disposed of in the repository is 14,350 cy.
- The initial repository excavation will be excavated to a depth of three feet, which will generate approximately 4,175 cubic yards of cover soil material. If shallow bedrock is encountered, the initial repository excavation will be less and additional cover soil will need to be obtained from elsewhere on site or imported from offsite.
- Bottom Liner - Based on the initial site reconnaissance, the material underlying the site area is assumed to be unsuitable for achieving the desired hydraulic conductivity barrier layer ($\leq 1 \times 10^{-7}$ cm/sec). Therefore, clay material would need to be imported, blended, and compacted with the native soil to provide the desired properties. This compacted base layer would be 3 feet deep, and soil lifts would be applied and compacted in 6-inch intervals.

**Table 7-6. Preliminary Cost Estimate for Alternative 4a: On-Site Disposal in a Constructed RCRA Subtitle C Repository**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 31,607 | $31,607 | 8% |
| Logistics | | | | | |
| Access Road | 1,200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 3.63 | Ac | 2,000 | $7,260 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| Install Temporary Bridge | 1 | LS | 15,000 | $15,000 | |
| Repository Construction | | | | | |
| Repository Base Grading | 0.98 | Ac | 2,000 | $1,960 | |
| Install Geotextile Cushion | 4,802 | SY | 3.00 | $14,406 | |
| Geosynthetic Clay Liner | 4,802 | SY | 4.50 | $21,609 | |
| 30 mil HDPE Liner | 4,802 | SY | 6.00 | $28,812 | |
| Geocomposite Drainage Layer | 4,802 | SY | 4.50 | $21,609 | |
| 30 mil HDPE Liner | 4,802 | SY | 6.00 | $28,812 | |
| Geocomposite Drainage Layer | 4,802 | SY | 4.50 | $21,609 | |
| Leachate Collection/Removal System | 1 | LS | 10,000 | $10,000 | |
| Waste Load, Haul & Dump | | | | | |
| Tailings | 10,000 | CY | 4.00 | $40,000 | |
| Waste Rock | 4,350 | CY | 4.00 | $17,400 | |
| Waste Grading and Compaction | 14,350 | CY | 2.00 | $28,700 | |
| Cap Construction | | | | | |
| Install Geotextile Cushion | 4,878 | SY | 3.00 | $14,634 | |
| Geosynthetic Clay Liner | 4,878 | SY | 4.50 | $21,951 | |
| Install Cap Liner (20 mil HDPE) | 4,878 | SY | 5.00 | $24,390 | |
| Geocomposite Drainage Layer | 4,878 | SY | 4.50 | $21,951 | |
| Cover Soil | 3,252 | CY | 6.00 | $19,512 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 800 | LF | 2.00 | $1,600 | |
| Revegetation | | | | | |
| Seed/Fertilize | 3.96 | Ac | 1,000 | $3,960 | |
| Mulch | 3.96 | Ac | 1,000 | $3,960 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Repository Fence | 1,000 | LF | 6.00 | $6,000 | |
| Subtotal | | | | $426,692 | |
| Construction Oversight | 15% | | | $64,004 | |
| Subtotal Capital Costs | | | | $490,696 | |
| Contingency | 10% | | | $49,070 | |
| TOTAL CAPITAL COSTS | | | | $539,765 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $539,765 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $566,208 | |

If the native soil is not capable of providing the desired low hydraulic conductivity, a GCL could be used in lieu of a three-feet-thick, compacted liner. The cost screening above assumes that sufficient native clay material is not available on site or near the site and a GCL is used for the base liner. A 30-mil-thick, HDPE flexible membrane liner would overlay the compacted base or GCL. A geotextile cushion layer would be placed under the GCL to protect it from being damaged.

- Secondary Leachate Collection/Removal Layer - A one-foot-thick layer of washed, coarse gravel would overlay the bottom liner. PVC drain pipes would be installed in conjunction with the coarse gravel layer for leachate collection/removal. A 30-mil thick, HDPE flexible membrane liner would overlay the secondary coarse gravel layer. If a sufficient source of washed, coarse gravel is not available on site or near the site, a geocomposite drainage layer could be used in lieu of a one-foot-thick washed gravel layer and PVC drain pipes. The cost screening above assumes that a geocomposite drainage layer is used for the secondary leachate collection system. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective drainage layer design (granular drainage vs. geocomposite).

- Primary Leachate Collection/Removal Layer - A one-foot-thick layer of washed, coarse gravel would overlay the secondary leachate collection/removal layer. PVC drain pipes would be installed in conjunction with the coarse gravel layer for leachate collection/removal. A geotextile filter fabric layer (to prevent potential clogging of the coarse gravel) would overlay the primary coarse gravel layer. If a sufficient source of washed, coarse gravel is not available on site or near the site, a geocomposite drainage layer could be used in lieu of a one-foot-thick washed gravel layer, PVC drain pipes and geotextile filter fabric layer. The cost screening above assumes that a geocomposite drainage layer is used in the primary leachate collection system. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective drainage layer design (granular drainage vs. geocomposite).

- The mine wastes would be deposited over the primary leachate collection system at an average depth of approximately 9 feet and a maximum thickness of 14 feet.

- Cap Liner - The native soil in the area of the repository is not expected to be adequate to provide the desired, low hydraulic conductivity barrier layer ($\leq 1 \times 10^{-7}$ cm/sec). Clay material could be imported, blended, and compacted with the native soil to provide the desired properties. This compacted layer would be 2 feet thick, and soil lifts would be applied and compacted in 6-inch intervals. If the native soil is not capable of providing the desired, low hydraulic conductivity, a GCL could be used in lieu of a two-feet-thick, compacted liner. The cost screening above assumes that a GCL is used in the cap liner system. A geotextile cushion layer would be placed beneath the GCL to protect it from being damaged. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective low-permeability liner system (compacted clay vs. GCL). A 20-mil-thick, HDPE flexible membrane liner would overlay the compacted soil layer or GCL.

- Drainage Layer - A one-foot-thick layer of washed, coarse gravel would overlay the compacted soil layer. A geotextile filter fabric layer (to prevent potential clogging of the coarse gravel) would overlay the coarse gravel drainage layer. If a sufficient source of washed, coarse gravel is not available on site or near the site, a geocomposite drainage layer could be used in lieu of a one-foot-thick washed gravel layer and filter fabric in the cap system. The cost screening above assumes that a geocomposite drainage layer is used in the cap liner system. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective cap drainage layer design (granular drainage vs. geocomposite).

- Vegetative Cover - A two-feet-thick layer of native soil would overlay the cap drainage layer. Cover soil sources will need to be identified during detailed site characterization.

- The surface area for grading and contouring of excavated source areas is 2.65 acres.

- Conventional plowing techniques would be adequate for preparing seed beds in the excavated source areas.

- The total surface area at the site requiring revegetation is approximately 3.96 acres (which includes the excavated source areas, Brandon Mill area, repository cap and haul roads).

- The total length of required runon/runoff control diversion ditches is approximately 800 lineal feet.

- A total of 5,020 lineal feet of 4-strand, barbed-wire fence and 1,000 lineal feet of repository fence will be constructed around the perimeter of the reclaimed areas.

Screening Summary

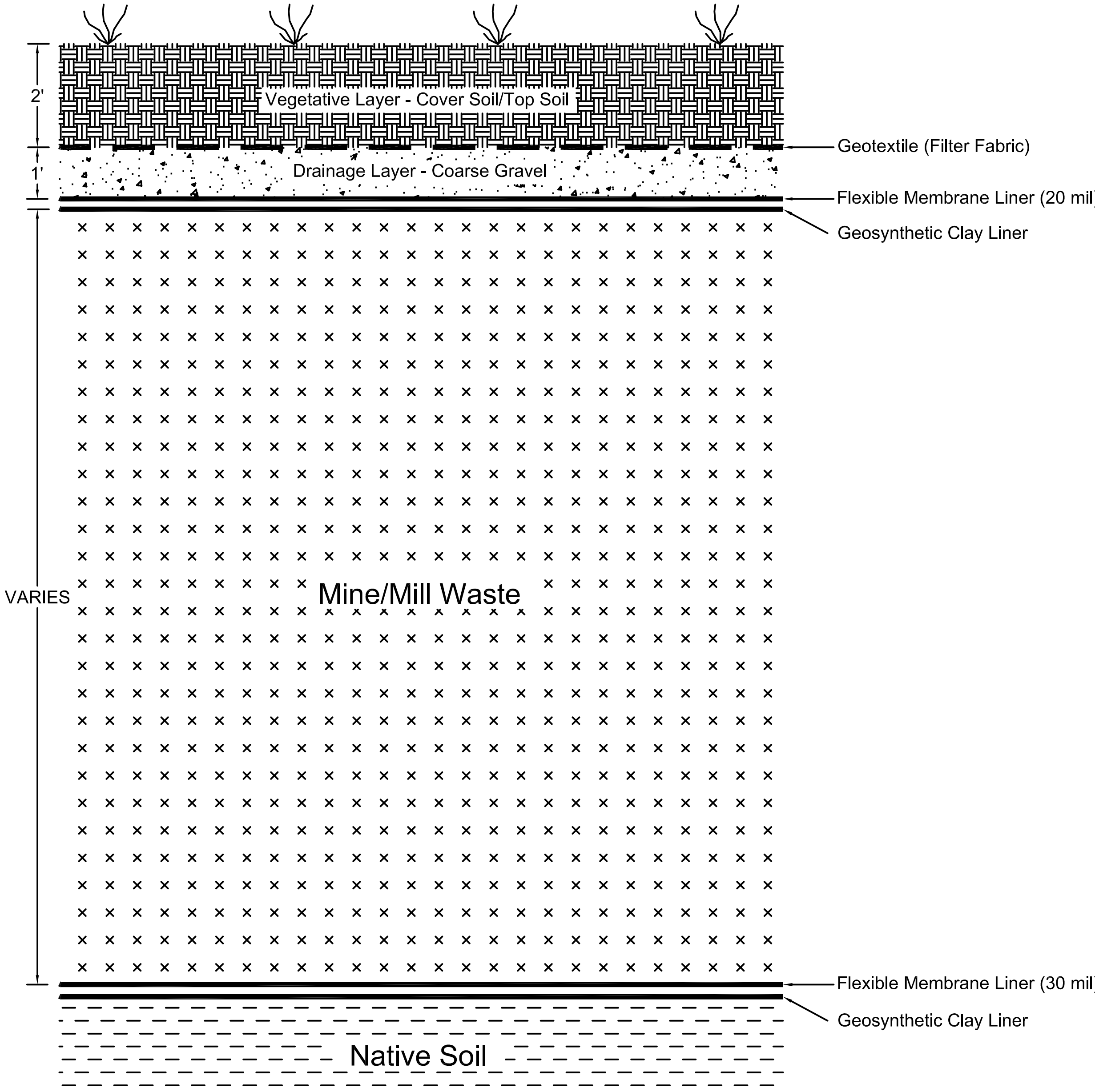
This alternative has been retained for detailed analysis because it provides the highest level of protection of the on-site disposal options.

#### 7.2.4.2 Alternative 4b: On-site Disposal in a Constructed Modified RCRA Repository

The reclamation strategy for Alternative 4b involves removing all identified waste sources at the Buckeye Mine and disposing these wastes in a constructed modified RCRA repository which includes a single composite liner (without a leachate collection and removal system) and a multi-layered cap (Figure 7-2).

It is assumed that the repository base can be excavated to a depth of three feet without interference from bedrock. The initial repository excavation will provide cover soil for capping the repository and reduce the overall height of the repository. If bedrock is encountered in the repository excavation, then additional cover soil will need to be recovered from elsewhere on site or from off site. After the repository area has been excavated and the surface prepared, a bottom liner would be installed. Once the waste sources are placed in the repository, a multi-layered cap would be constructed overlying the waste, and the repository cap would be revegetated. A runon/runoff control ditch would be constructed in the area of the repository to divert surface water away from the repository cap.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure disposal facility. Consequently, the surface water erosion problems associated with the site are expected to be mitigated. Contaminant toxicity and volume would not be reduced, however, the waste would be rendered immobile in a structure and physical location protected




| | | | | | |
|---|---|---|---|---|---|
| Olympus Technical Services, Inc. | | | | ALTERNATIVE 4B - ONSITE DISPOSAL IN A MODIFIED RCRA REPOSITORY | FIGURE 7-2 |
| Drawn: KSR | Checked: CRS | Date: 4/2005 | Job No: A1475 | MONTANA DEQ/MINE WASTE CLEANUP BUREAU<br>BUCKEYE MINE RECLAMATION PROJECT<br>MADISON COUNTY, MONTANA | |
| Design: | Approved: | Scale: NONE | File: A1475-4B.dwg | | |

from erosion problems. Infiltration of precipitation through the waste sources and resulting migration of contaminants through the vadose zone and ground water would also be significantly reduced. Long-term monitoring and control programs would be established to ensure continued effectiveness.

This alternative is not expected to provide as high a degree of effectiveness as provided by a constructed repository which complies with all RCRA Subtitle C regulations (Alternative 4a), however, this alternative may provide adequate protection at a significantly reduced cost. Although this alternative does not comply with EPA's Minimum Technology Guidance (EPA, 1989b), the design may provide adequate environmental protection considering the chemical and physical characteristics of the mine waste in conjunction with the physical location of the repository site and the area's generally semi-arid climate. EPA's HELP Model could be applied to the conceptual design to determine the relative effectiveness of the design and ultimately to determine the overall feasibility of the alternative and associated cost effectiveness.

Implementability - This alternative is both technically and administratively feasible. The construction steps required are considered conventional construction practices. Key project components, such as the availability of equipment, materials, and construction expertise, are all present and would help ensure the timely implementation and successful execution of the proposed plan.

Cost Screening - The total present-worth cost for this alternative has been estimated at $434,457 which represents the reclamation of all the tailings and waste rock piles present at the Buckeye Mine. Table 7-7 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs. The cost estimate assumes that a geocomposite drainage layer is used in the cap liner system rather than washed coarse gravel.

The following assumptions were used to develop costs for this alternative:

- Requires approximately 1,200 feet of single-lane access road improvement with turnouts.

- The total volume of waste material to be excavated and disposed of in the repository is 14,350 cy.

- The initial repository excavation will be excavated to a depth of three feet, which will generate approximately 4,175 cubic yards of cover soil material. If shallow bedrock is encountered, the initial repository excavation will be less and cover soil will need to be obtained from elsewhere on site or imported from offsite.

- Bottom Liner - A GCL would be installed in the repository base. A 30-mil-thick, HDPE flexible membrane liner would overlay the GCL.

- The mine wastes would be deposited over the flexible membrane liner at an average depth of approximately 9 feet and a maximum thickness of 14 feet.

- Cap Liner - A GCL would be installed overlaying the mine waste. A 20-mil-thick, HDPE flexible membrane liner would overlay the GCL.

**Table 7-7. Preliminary Cost Estimate for Alternative 4b: On-Site Disposal in a Constructed Modified RCRA Repository**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 23,892 | $23,892 | 8% |
| Logistics | | | | | |
| Access Road | 1,200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 3.63 | Ac | 2,000 | $7,260 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| Install Temporary Bridge | 1 | LS | 15,000 | $15,000 | |
| Repository Construction | | | | | |
| Repository Base Grading | 0.98 | Ac | 2,000 | $1,960 | |
| Install Geosynthetic Clay Liner | 4,802 | SY | 4.50 | $21,609 | |
| Install 30 mil Flexible Membrane Liner | 4,802 | SY | 6.00 | $28,812 | |
| Waste Load, Haul & Dump | | | | | |
| Tailings | 10,000 | CY | 4.00 | $40,000 | |
| Waste Rock | 4,350 | CY | 4.00 | $17,400 | |
| Waste Grading and Compaction | 14,350 | CY | 2.00 | $28,700 | |
| Cap Construction | | | | | |
| Install Geotextile Cushion | 4,878 | SY | 3.00 | $14,634 | |
| Install Geosynthetic Clay Liner | 4,878 | SY | 4.50 | $21,951 | |
| Install Cap Liner (20 mil HDPE) | 4,878 | SY | 5.00 | $24,390 | |
| Geocomposite Drainage Layer | 4,878 | SY | 4.50 | $21,951 | |
| Cover Soil | 3,252 | CY | 6.00 | $19,512 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 800 | LF | 2.00 | $1,600 | |
| Revegetation | | | | | |
| Seed/Fertilize | 3.96 | Ac | 1,000 | $3,960 | |
| Mulch | 3.96 | Ac | 1,000 | $3,960 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Repository Fence | 1,000 | LF | 6.00 | $6,000 | |
| Subtotal | | | | $322,541 | |
| Construction Oversight | 15% | | | $48,381 | |
| Subtotal Capital Costs | | | | $370,922 | |
| Contingency | 10% | | | $37,092 | |
| TOTAL CAPITAL COSTS | | | | $408,014 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $408,014 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $434,457 | |

- Drainage Layer - A one-foot-thick layer of washed, coarse gravel would overlay the composite cap liner system. A geotextile filter fabric layer (to prevent potential clogging of the coarse gravel) would overlay the coarse gravel drainage layer. If a sufficient source of washed, coarse gravel is not available on site or near the site, a geocomposite drainage layer could be used in lieu of a one-foot-thick washed gravel layer in the cap system. The cost screening above assumes that a geocomposite drainage layer is used in the cap liner system. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective cap drainage layer design (granular drainage vs. geocomposite).

- Vegetative Cover - A two-feet-thick layer of native soil would overlay the cap drainage layer. Cover soil sources will need to be identified during detailed site characterization.

- The surface area for grading and contouring of excavated source areas is 2.65 acres.

- Conventional plowing techniques would be adequate for preparing seed beds in the excavated source areas.

- The total surface area at the site requiring revegetation is approximately 3.96 acres (which includes the excavated source areas, Brandon Mill area, repository cap and haul roads).

- The total length of required runon/runoff control diversion ditches is approximately 800 lineal feet.

- A total of 5,020 lineal feet of 4-strand, barbed-wire fence and 1,000 lineal feet of repository fence will be constructed around the perimeter of the reclaimed areas.

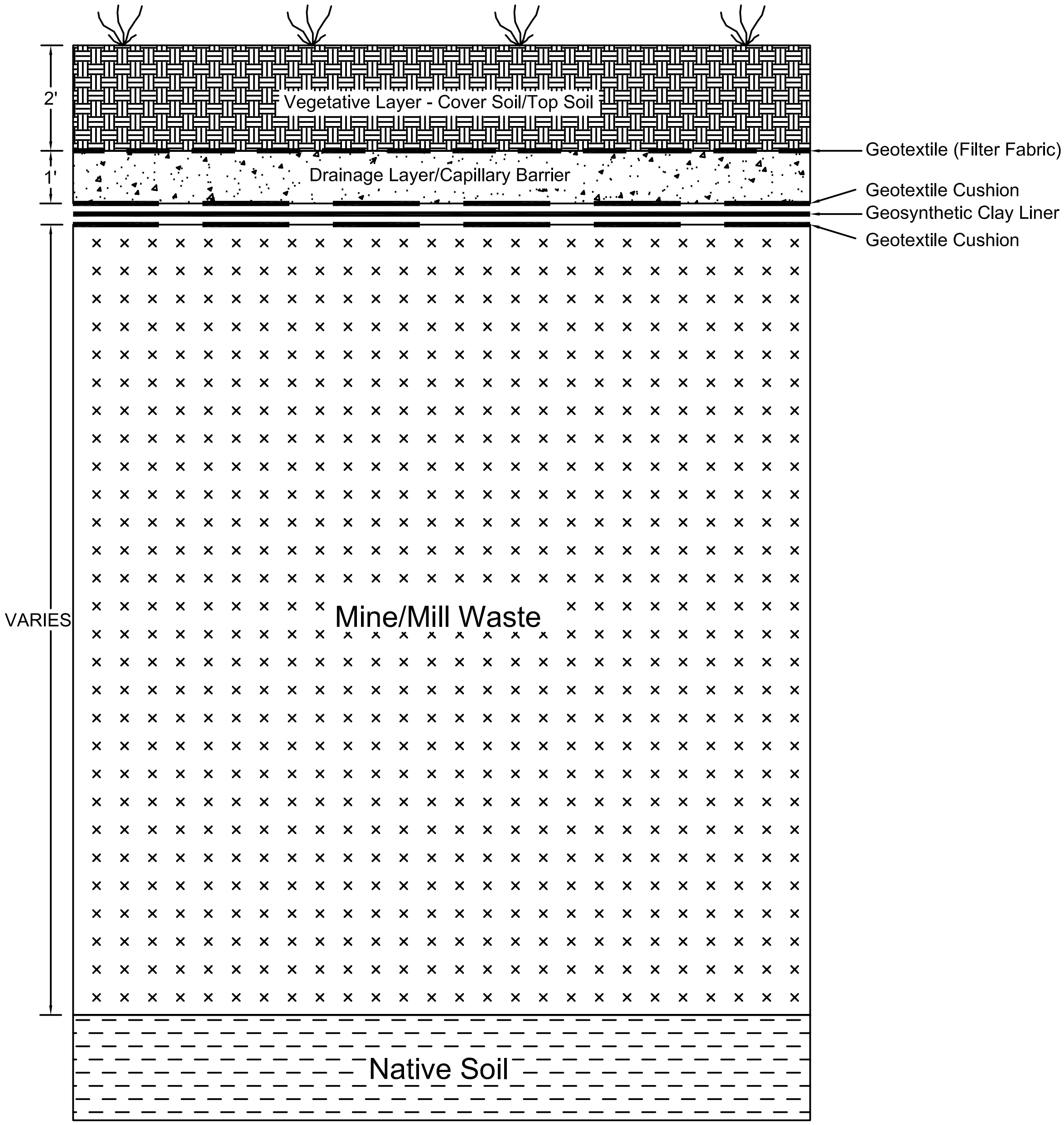
<u>Screening Summary</u>

This alternative has been retained for detailed analysis since it is the most cost-effective alternative that provides for total encapsulation of the waste in an on-site repository.

#### 7.2.4.3 Alternative 4c: On-site Disposal in a Constructed Unlined Repository with a Multi-Layered Cap

The reclamation strategy for Alternative 4c involves removing all identified waste sources at the Buckeye Mine and disposing these wastes in a constructed, unlined repository with a multi-layered cap (Figure 7-3).

<u>Effectiveness</u> - This alternative would effectively reduce contaminant mobility at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure disposal facility. Consequently, the surface water erosion problems associated with the site are expected to be mitigated. Contaminant toxicity and volume would not be reduced, however, the waste would be rendered immobile in a structure and physical location protected from erosion problems. Infiltration of precipitation through the waste sources and resulting migration of contaminants through the vadose zone and ground water would also be significantly reduced. Long-term monitoring and control programs would be established to ensure continued effectiveness.




| | | | |
|---|---|---|---|
| **Olympus Technical Services, Inc.** | | ALTERNATIVES 4C - ONSITE DISPOSAL IN AN UNLINED REPOSITORY WITH A MULTI-LAYERED CAP | FIGURE 7-3 |
| Drawn: KSR | Checked: CRS | Date: 4/2005 | Job No: A1475 |
| Design: | Approved: | Scale: NONE | File: A1475-4C.dwg |

MONTANA DEQ/MINE WASTE CLEANUP BUREAU
BUCKEYE MINE RECLAMATION PROJECT
MADISON COUNTY, MONTANA

This alternative is not expected to provide as high a degree of effectiveness as provided by a constructed repository which complies with all RCRA Subtitle C regulations (Alternative 4a) or a lined repository (Alternative 4b), however, this alternative may provide adequate protection at a significantly reduced cost. Although this alternative does not comply with EPA's Minimum Technology Guidance (EPA, 1989b), the design may provide adequate environmental protection considering the chemical and physical characteristics of the mine waste in conjunction with the physical location of the repository site and the area's generally semi-arid climate. EPA's HELP Model (EPA, 1997) could be applied to the conceptual design to determine the relative effectiveness of the design and ultimately to determine the overall feasibility of the alternative and associated cost effectiveness.

Implementability - This alternative is both technically and administratively feasible. The construction steps required are considered conventional construction practices. Key project components, such as the availability of equipment, materials, and construction expertise, are all present and would help ensure the timely implementation and successful execution of the proposed plan.

Cost Screening - The total present-worth cost for this alternative has been estimated at $352,243 which represents the reclamation of all the tailings and waste rock piles present at the Buckeye Mine. Table 7-8 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs. The cost estimate assumes that a geocomposite drainage layer is used in the cap liner system rather than washed coarse gravel.

The following assumptions were used to estimate the costs associated with this alternative:

- Requires approximately 1,200 feet of single-lane access road improvement with turnouts.

- The total volume of waste material to be excavated and disposed of in the repository is 14,350 cy.

- The mine wastes would be deposited at an average depth of approximately 9 feet and a maximum thickness of 14 feet.

- Cap Liner - A GCL would be installed overlaying the mine waste. A geotextile cushion layer would be installed above and below the GCL to protect it from being damaged.

- Drainage Layer - A one-foot-thick layer of washed, coarse gravel would overlay the composite cap liner system. A geotextile filter fabric layer (to prevent potential clogging of the coarse gravel) would overlay the coarse gravel drainage layer. If a sufficient source of washed, coarse gravel is not available on site or near the site, a geocomposite drainage layer could be used in lieu of a one-foot-thick washed gravel layer in the cap system. The cost screening above assumes that a geocomposite drainage layer is used in the cap liner system. A cost/benefit analysis would be performed during the detailed evaluation of reclamation alternatives to determine the most cost-effective cap drainage layer design (granular drainage vs. geocomposite).

- Vegetative Cover - A two-feet-thick layer of native soil would overlay the cap drainage layer. Cover soil sources will need to be identified during detailed site characterization.

**Table 7-8. Preliminary Cost Estimate for Alternative 4c: On-Site Disposal in a Constructed Unlined Repository with a Multi-Layered Cap**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 19,078 | $19,078 | 8% |
| Logistics | | | | | |
| Access Road | 1,200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 3.63 | Ac | 2,000 | $7,260 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| Install Temporary Bridge | 1 | LS | 15,000 | $15,000 | |
| Repository Construction | | | | | |
| Repository Base Grading | 0.98 | Ac | 2,000 | $1,960 | |
| Waste Load, Haul & Dump | | | | | |
| Tailings | 10,000 | CY | 4.00 | $40,000 | |
| Waste Rock | 4,350 | CY | 4.00 | $17,400 | |
| Waste Grading and Compaction | 14,350 | CY | 2.00 | $28,700 | |
| Cap Construction | | | | | |
| Install Geotextile Cushion | 4,878 | SY | 3.00 | $14,634 | |
| Install Geosynthetic Clay Liner | 4,878 | SY | 4.50 | $21,951 | |
| Install Geotextile Cushion | 4,878 | SY | 3.00 | $14,634 | |
| Geocomposite Drainage Layer | 4,878 | SY | 4.50 | $21,951 | |
| Cover Soil | 3,252 | CY | 6.00 | $19,512 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 800 | LF | 2.00 | $1,600 | |
| Revegetation | | | | | |
| Seed/Fertilize | 3.96 | Ac | 1,000 | $3,960 | |
| Mulch | 3.96 | Ac | 1,000 | $3,960 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Repository Fence | 1,000 | LF | 6.00 | $6,000 | |
| Subtotal | | | | $257,550 | |
| Construction Oversight | 15% | | | $38,633 | |
| Subtotal Capital Costs | | | | $296,183 | |
| Contingency | 10% | | | $29,618 | |
| TOTAL CAPITAL COSTS | | | | $325,801 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $325,801 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $352,243 | |

- The surface area for grading and contouring of excavated source areas is 2.65 acres.
- Conventional plowing techniques would be adequate for preparing seed beds in the excavated source areas.
- The total surface area at the site requiring revegetation is approximately 3.96 acres (which includes the excavated source areas, Brandon Mill area, repository cap and haul roads).
- The total length of required runon/runoff control diversion ditches is approximately 800 lineal feet.
- A total of 5,020 lineal feet of 4-strand, barbed-wire fence and 1,000 lineal feet of repository fence will be constructed around the perimeter of the reclaimed areas.

Screening Summary

This alternative has been retained for detailed analysis due to its potential to meet reclamation goals with a proven technology.

### 7.2.5 Alternative 5: Off-Site Disposal in a Permitted Solid Waste Disposal Facility

The reclamation strategy for Alternative 5 involves removing all identified waste sources at the Buckeye Mine and disposing of these wastes in a Class II Municipal Solid Waste (MSW) Landfill. The sources to be disposed of include the four tailings piles and the five waste rock piles. The nearest disposal facility is the Beaverhead County Landfill, located near Dillon, which is permitted for Class II solid wastes.

In order for the waste to be accepted at a Class II MSW landfill, it would have to pass the Toxicity Characteristic Leaching Procedure (TCLP) test. Neither the mill tailings nor the waste rock were tested according to TCLP methods during the preliminary assessment. The tailings and waste rock materials of concern are derived from the beneficiation and extraction of ores and are therefore exempt from federal regulation under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 (b) (3) (A)(iii)(1994) as a hazardous waste.

A considerable amount of heavy equipment/machinery would be necessary to efficiently implement this alternative. To excavate and load out the contaminated material, as well as construct runon/runoff control structures, equipment requirements would include, but not be limited to, multiple bulldozers, front end loaders and excavators. Haul trucks would be used to transport the material to the facility, which is located approximately 40 miles southwest of the site. The number of haul trucks and loaders would have to be selected and scheduled very carefully to optimize loading cycle times and reduce construction costs as much as possible.

After the excavation and loadout are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level out and contour the areas to match the surrounding terrain. The seed beds would be prepared using conventional agricultural plowing. Seeding would take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Disturbed surfaces are susceptible to erosion until vegetation is established. Therefore, mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by completely removing the highest risk solid media contaminant sources from the site. Contaminant toxicity and volume would not be reduced. Removal of wastes to a Class II MSW landfill facility provides long-term monitoring and control programs to ensure continued effectiveness. However, short-term risks of exposure to the contaminated material may occur during transport to the disposal facility.

Implementability - This alternative is technically feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of personnel, equipment and materials, are present and would help allow the timely implementation and successful execution of the proposed plan. The administrative feasibility is questionable based on the waste disposal regulatory rules, landfill permit requirements, and multiple agency approval requirements, and the negative perception of the waste.

Cost Screening - The total present-worth cost for this alternative has been estimated at $1,132,915 which represents the reclamation of all the tailings and waste rock piles present at the Buckeye Mine. Table 7-9 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

The following assumptions were used to estimate the costs associated with this alternative:

- Requires approximately 1,200 feet of single-lane access/haul road improvement with turnouts.
- Based on the estimated waste volume of 14,350 cy, the total tonnage of waste material to be removed from the site has been estimated at 20,090 tons.
- The waste material would be hauled by truck to the Beaverhead County Landfill, located near Dillon, Montana.
- Conventional plowing techniques would be adequate for preparing seed beds in the excavated areas.
- The surface area for grading and contouring of excavated source areas is 2.65 acres.
- The total surface area at the site requiring revegetation is approximately 2.98 acres (which includes the excavated source areas, Brandon Mill area and haul roads).
- A total of 5,020 lineal feet of 4-strand, barbed-wire fence will be constructed around the perimeter of the reclaimed areas.

Screening Summary

This alternative has not been retained for further evaluation due to the high cost and questionable administrative feasibility. A similar degree of relative effectiveness can be obtained by other alternatives being evaluated at significantly reduced costs.

**Table 7-9. Preliminary Cost Estimate for Alternative 5: Off-Site Disposal of Tailings in a Permitted Solid Waste Disposal Facility**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | LS | 65,277 | $65,277 | 8% |
| Logistics | | | | | |
| Access Road | 1,200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 2.98 | Ac | 2,000 | $5,960 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| Waste Load, Haul & Dump | | | | | |
| Waste Excavation & Loading | 14,350 | CY | 2.00 | $28,700 | |
| Decon | 14,350 | CY | 0.25 | $3,588 | |
| Transportation | | | | | |
| Transportation to Disposal Facilty | 18,225 | CY | 17.00 | $309,825 | 27% Swell |
| DISPOSAL | | | | | |
| Disposal Charge | 20,090 | Ton | 22.00 | $441,980 | Disp. Facility Estimate |
| Revegetation | | | | | |
| Seed/Fertilize | 2.98 | Ac | 1,000 | $2,980 | |
| Mulch | 2.98 | Ac | 1,000 | $2,980 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Subtotal | | | | $881,240 | |
| Construction Oversight | 15% | | | $132,186 | |
| Subtotal Capital Costs | | | | $1,013,425 | |
| Contingency | 10% | | | $101,343 | |
| TOTAL CAPITAL COSTS | | | | $1,114,768 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $1,750 | |
| Contingency | 10% | | | $175 | |
| TOTAL ANNUAL O&M COST | | | | $1,925 | |
| TOTAL CAPITAL COSTS | | | | $1,114,768 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $18,147 | |
| **TOTAL PRESENT WORTH COST** | | | | $1,132,915 | |

### 7.2.6 Alternative 6: Off-Site Disposal in a RCRA-Permitted Hazardous Waste Disposal Facility

The reclamation strategy for Alternative 6 involves removing all identified waste sources at the Buckeye Mine and disposing of these wastes in a RCRA-permitted hazardous waste disposal facility, pending profiling and acceptance of the waste at the disposal facility. The sources to be disposed of include the four tailings piles and the five waste rock piles. The two nearest RCRA-permitted hazardous waste disposal facilities with the capacity to dispose of the wastes are both located several hundred miles from the site (one facility is located in Idaho, the other in Oregon).

A considerable amount of heavy equipment would be necessary to efficiently implement this alternative. To load out the contaminated material, equipment requirements would include, but not be limited to, multiple bulldozers, front end loaders, and excavators. Haul trucks would be used to transport the material to a local rail facility (probably in Twin Bridges), where it would be transferred into gondola cars and shipped by rail to the RCRA facility. The field procedure would first involve constructing a single lane haul road with turnouts in the vicinity of the waste sources at the site to allow unobstructed access for haul trucks.

After the excavation and loadout are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level out and contour the areas to match the surrounding terrain. The seed beds would be prepared using conventional agricultural plowing. It is recommended that seeding take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Disturbed surfaces are susceptible to erosion until vegetation is established. Therefore, mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by removing the contaminant sources. Consequently, the site problems are expected to be permanently corrected. Contaminant toxicity and volume would not be reduced, but would be permanently transferred to a different physical location. Disposal at a RCRA-permitted facility establishes long-term monitoring and control programs to enhance continued effectiveness. However, short-term risks of exposure to the contaminated material would occur during transport to the disposal facility.

Implementability - This alternative is both technically and administratively feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of equipment, materials, and a RCRA facility with adequate capacity, are present and would allow for the timely implementation and successful execution of the proposed plan.

Cost Screening - The total present-worth cost for this alternative has been estimated at $3,266,714 which represents the reclamation of all of the tailings and waste rock piles present at the Buckeye Mine. Table 7-10 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

The following assumptions were used to estimate the costs associated with this alternative:

**Table 7-10. Preliminary Cost Estimate for Alternative 6: Off-Site Disposal in a RCRA-Permitted Hazardous Waste Disposal Facility**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 190,225 | $190,225 | 8% |
| Logistics | | | | | |
| Access Road | 1,200 | LF | 2.00 | $2,400 | |
| Site Clearing/Preparation | 2.98 | Ac | 2,000 | $5,960 | |
| Debris Removal and Onsite Disposal | 1 | LS | 5,000 | $5,000 | |
| Waste Load, Haul & Dump | | | | | |
| Waste Excavation & Loading | 14,350 | CY | 2.00 | $28,700 | |
| Waste Hauling to Rail Transfer | 18,225 | CY | 9.00 | $164,025 | 27% Swell |
| Decon | 14,350 | CY | 0.25 | $3,588 | |
| Rail Transportation | | | | | |
| Transportation to Disposal Facilty | 20,090 | Ton | 37.00 | $743,330 | Rail Shipment Estimate |
| DISPOSAL | | | | | |
| Profiling Charge | 1 | LS | 200.00 | $200 | Disp. Facility Estimate |
| Profiling Charge Credit | 1 | LS | -200.00 | ($200) | Disp. Facility Estimate |
| Disposal Charge | 20,090 | Ton | 45.00 | $904,050 | Disp. Facility Estimate |
| Tax Charge | 20,090 | Ton | 25.00 | $502,250 | Disp. Facility Estimate |
| Revegetation | | | | | |
| Seed/Fertilize | 2.98 | Ac | 1,000 | $2,980 | |
| Mulch | 2.98 | Ac | 1,000 | $2,980 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,020 | LF | 2.50 | $12,550 | |
| Subtotal | | | | $2,568,038 | |
| Construction Oversight | 15% | | | $385,206 | |
| Subtotal Capital Costs | | | | $2,953,243 | |
| Contingency | 10% | | | $295,324 | |
| TOTAL CAPITAL COSTS | | | | $3,248,567 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $1,750 | |
| Contingency | 10% | | | $175 | |
| TOTAL ANNUAL O&M COST | | | | $1,925 | |
| TOTAL CAPITAL COSTS | | | | $3,248,567 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $18,147 | |
| **TOTAL PRESENT WORTH COST** | | | | $3,266,714 | |

- Requires approximately 1,200 feet of single-lane access road improvement with turnouts.
- Based on the estimated waste volume of 14,350 cy, the total tonnage of waste material to be removed from the site has been estimated at 20,090 tons.
- The waste material would be hauled by truck to a suitable transfer area (probably in Twin Bridges), where it would be loaded out and shipped by rail.
- The surface area for grading and contouring of excavated source areas is 2.65 acres.
- Conventional plowing techniques would be adequate for preparing seed beds in the excavated areas.
- The total surface area at the site requiring revegetation is approximately 2.98 acres (which includes the excavated source areas, Brandon Mill area and haul roads).
- A total of 5,020 lineal feet of 4-strand, barbed-wire fence will be constructed around the perimeter of the reclaimed areas.

Screening Summary

This alternative has not been retained for further evaluation due to extremely high costs. A similar degree of relative effectiveness can be obtained by several other alternatives being evaluated at significantly reduced costs.

## 7.3 ALTERNATIVES SCREENING SUMMARY

Table 7-11 summarizes the findings of the alternatives screening exercise. Costs generated and summarized in Table 7-11 are present-worth values which include construction costs, as well as operation/monitoring and maintenance costs, for a 30-year period. These cost estimates are order-of-magnitude estimates generated for planning purposes. Cost estimates will be refined during the detailed analysis of alternatives after the site has been more accurately characterized.

Off-site disposal in licensed and permitted solid waste (Alternative 5) and RCRA disposal facilities (Alternative 6) will not be retained for detailed analysis due to the high costs. A similar degree of effectiveness could be attained at a significantly reduced cost by implementing other alternative(s).

## 7.4 ALTERNATIVES REFINEMENT PROCESS

The alternatives development and screening process developed a variety of reclamation alternative derivatives for the Buckeye Mine project. A total of eight reclamation alternatives including the no action alternative, as well as several variations of Alternative 4 were preliminarily developed, presented, and evaluated in the Reclamation Work Plan (DEQ-MWCB/Olympus, 2004e) and reviewed in Section 7.2. Of the eight alternatives evaluated, five were recommended for further "detailed" analysis. However, additional data from the site characterization support eliminating two of the recommended alternatives.

**TABLE 7-11. ALTERNATIVES SCREENING SUMMARY**

| ALTERNATIVE DESCRIPTION | EFFECTIVE | IMPLEMENTABLE | COST ESTIMATE | RETAINED FOR DETAILED ANALYSIS |
|---|---|---|---|---|
| ALT. 1: No Action | NA | NA | $0 | Yes |
| ALT. 2: Institutional Controls | Low | Yes | $177,271 | No |
| ALT. 3: Partial Consolidation/In-Place Containment | Medium | Yes | $140,281 | Yes |
| ALT. 4a: On-site Disposal in RCRA Subtitle C Repository | High | Yes | $566,208 | Yes |
| ALT. 4b: On-site Disposal in Constructed Modified RCRA Repository | High | Yes | $434,457 | Yes |
| ALT. 4c: On-site Disposal in a Constructed Unlined Repository With a Multi-layered Cap | Medium-High | Yes | $352,243 | Yes |
| ALT. 5: Off-Site Disposal - Solid Waste Permitted Facility | High | Questionable | $1,132,915 | No |
| ALT. 6: Off Site Disposal - RCRA Permitted Hazardous Waste Facility | High | Yes | $3,266,714 | No |

The waste characterization data indicate that several of the waste sources are potentially acid generating (TP-4, TP-5, WR-4, WR-5 and the Brandon Mill area) or exceed TCLP regulatory levels for lead (TP-3, TP-4, WR-4, WR-5 and the Brandon Mill area). These waste characteristics do not support institutional controls (as a stand-alone alternative) or in-place containment of wastes. Therefore, Alternatives 2 and 3 will be eliminated from detailed analyses. Table 7-12 presents the final alternatives that will be retained for detailed analysis.

**TABLE 7-12. ALTERNATIVES RETAINED FOR DETAILED ANALYSIS**

| | |
|---|---|
| Alternative 1: | No Action |
| Alternative 4a: | On-Site Disposal in a Constructed RCRA Repository |
| Alternative 4b: | On-Site Disposal in a Constructed Modified RCRA Repository |
| Alternative 4c: | On-Site Disposal in a Constructed Unlined Repository with a Multi-Layered Cap |

The site characterization did not reveal the presence of significant borrow sources for clay liner material in the vicinity of the site. Importing clay suitable for liner construction for a RCRA repository would be very expensive. Therefore, the repository design for Alternative 4a will utilize a GCL in lieu of a compacted clay liner. Additionally, the repository design for Alternative 4b will be modified so that no flexible membrane liners are included in the base or cap liner system.

# 8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES

The purpose of the detailed analysis is to evaluate, in further detail, reclamation alternatives for their effectiveness, implementability, and cost to control and reduce the toxicity, mobility, and/or volume of contaminated mine/mill wastes associated with the Buckeye Mine site. Only those reclamation alternatives which were retained after the preliminary evaluation in Section 7.2 and were further screened in the Section 7.4 alternative refinement process are included. Each reclamation alternative currently being considered for implementation for the Buckeye Mine site is classifiable as an interim or removal action and is not a complete remediation action. The reclamation alternatives are applicable to the contaminated solid media only; no reclamation alternatives have been developed or evaluated for active treatment of groundwater, surface water, or off-site stream sediments. The rationale for not directly developing remedial alternatives for these environmental media was based primarily on the presumption that reclaiming the contaminant source(s) will subsequently reduce or eliminate the problems associated with surface water, groundwater, and off-site stream sediments at a significantly reduced cost.

As required by the CERCLA and the NCP, reclamation alternatives that were retained after the initial evaluation and screening have to be evaluated individually against the following criteria:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

Supporting agency acceptance and community acceptance are additional criteria that will be addressed after DEQ-MWCB and the public have a chance to review the evaluations presented. The analysis criteria have been used to address the CERCLA requirements and considerations with EPA guidance (EPA, 1988), as well as additional technical and policy considerations. These analysis criteria serve as the basis for conducting the detailed analysis and subsequently selecting the preferred reclamation alternative. The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- Threshold Criteria - overall protection of human health and the environment and compliance with ARARs;
- Primary Balancing Criteria - long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; and
- Modifying Criteria - state and community acceptance.

Overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing factors used to weigh major trade-offs between alternative waste management strategies. Supporting agency and community acceptance are modifying considerations that are formally considered after public comment is received on the proposed plan and the Expanded EE/CA report (Federal Register, No. 245, 51394-50509, December 1988). Each of these criteria is briefly described in the following paragraphs.

Compliance with ARARs criteria assesses how each alternative complies with applicable or relevant and appropriate standards, criteria, advisories, or other guidelines. Waivers will be identified, if necessary. The following factors will be addressed for each alternative during the detailed analysis of ARARs:

- compliance with chemical-specific ARARs;
- compliance with action-specific ARARs;
- compliance with location-specific ARARs; and
- compliance with appropriate criteria, advisories, and guidelines.

Long-term effectiveness and permanence evaluates the alternative's effectiveness in protecting human health and the environment after response objectives have been met. The following components of the criteria will be addressed for each alternative:

- magnitude of remaining risk;
- adequacy of controls; and
- reliability of controls.

The reduction of toxicity, mobility, or volume assessment evaluates anticipated performance of the specific treatment technologies. This evaluation focuses on the following specific factors for a particular reclamation alternative:

- the treatment process, the remedies they will employ, and the materials they will treat;
- the amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed;
- the degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- degree to which the treatment will be irreversible; and
- the type and quantity of treatment residuals that will remain following treatment.

Short-term effectiveness evaluates an alternative's effectiveness in protecting human health and the environment during the construction and implementation period until the response objectives are met. Factors that will be considered under this criteria include:

- protection of the surrounding community during reclamation actions;
- protection of on-site workers during reclamation actions;
- protection from environmental impacts; and
- time until removal response objectives are achieved.

Implementability evaluates the technical and administrative feasibility of alternatives and the availability of required resources. Analysis of this criterion will include the following factors and subfactors:

Technical Feasibility

- construction and operation;
- reliability of technology;
- ease of undertaking additional remedial action; and
- monitoring considerations.

Administrative Feasibility

- RCRA disposal restrictions;
- institutional controls; and
- permitting requirements.

Availability of Services and Materials

- adequate off-site treatment, storage capacity, and disposal service;
- necessary equipment and specialists and provisions to ensure any necessary additional resources;
- timing of the availability of technologies under consideration; and
- services and materials.

The cost assessment evaluates the capital and operation and maintenance (O&M) costs of each alternative. A present-worth analysis based on a 10-percent inflation rate and a maximum design life of 30 years will be used to compare alternatives. Cost screening consists of developing conservative, order-of-magnitude cost estimates based on similar sets of site-specific assumptions. Cost estimates for each alternative will consider the following factors:

Capital Costs

- construction costs;
- equipment costs;
- land and site development costs;
- disposal costs;
- engineering design;
- legal fees, license, and permit costs;
- startup and troubleshooting costs; and
- contingency allowances.

Annual Costs

- operating labor;
- maintenance materials and labor;
- auxiliary materials and energy;
- disposal residues;
- purchased services (i.e., sampling costs, laboratory fees, professional fees);
- administrative costs;
- insurance, taxes, and licensing;
- maintenance reserve and contingency funds;
- rehabilitation costs; and
- periodic site reviews.

Supporting agency acceptance will evaluate the technical and administrative issues and concerns the state may have regarding each of the alternatives. State acceptance will also focus on legal issues and compliance with state statutes and regulations. Community acceptance will incorporate public concerns into the analyses of the alternatives.

The final step of this process is to conduct a comparative analysis of the alternatives. The analysis will include a discussion of the alternative's relative strengths and weaknesses with respect to each of the criteria and how reasonable key uncertainties could change expectations of their relative performance.

Once completed, this evaluation will be used to select the preferred alternative(s). The selection of the preferred alternative(s) will be documented in a Record of Decision. Public meetings to present the alternatives will be conducted and significant oral and written comments will be addressed in writing.

## 8.1 ALTERNATIVE 1: NO ACTION

The no action alternative means that no reclamation is done at the site to control contaminant migration or to reduce toxicity or volume. This option would require no further reclamation investigation or monitoring action at the site. The no action response is generally used as a baseline against which other reclamation options can be compared. This alternative has been retained for further evaluation as suggested by the NCP.

### 8.1.1 Overall Protection of Human Health and the Environment

The no action alternative provides no control of exposure to the contaminated materials and no reduction in risk to human health or the environment. It allows for the continued migration of contaminants and further degradation of water and air.

Protection of human health would not be achieved under the no action alternative. Prevention of direct human exposure via the pathways of concern would not be achieved. Carcinogenic risk from ingestion of arsenic via water/fish ingestion under both the recreational and residential scenarios may be reduced to 1E-06; however, this is unknown because the laboratory detection limit for arsenic was greater than the cleanup goal. Noncarcinogenic risk from soil ingestion/dust inhalation of lead would not be reduced to below cleanup goals under the recreational risk scenario. Noncarcinogenic risk from soil ingestion/dust inhalation of antimony, arsenic, iron and lead would not be reduced to below cleanup goals under the residential risk scenario. Carcinogenic risk from soil ingestion/dust inhalation of arsenic would not be reduced to 1E-06 under both the recreational and residential scenarios.

Protection of the environment would also not be achieved under the no action alternative. Prevention of ecological exposures via exposure to water, sediment and soil sources would not be achieved. Deer exposure to lead via ingestion of tailings salts would not be reduced below cleanup goals. Plant phytotoxicity to arsenic, cadmium, copper, lead and zinc would not be reduced below cleanup goals. A risk reduction achievement matrix for the various pathways and contaminants, identified in the baseline human health risk assessment and the ecological risk assessment, is shown in Table 8-1.

**Table 8-1. Risk Reduction Achievement Matrix for Alternative 1**

| Exposure Pathway | Risk Level | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Human Risk - Residential: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion | HQ=1 | | | | | | | | | | | | | | | | | | |
| Pathway (µg/l) | Carc. 1E-06 | | | 0.045 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | 31 | No | 23 | No | | | | | 23000 | No | 400 | No | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 0.43 | No | | | | | | | | | | | | | | |
| Human Risk - Recreational: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion/Fish | HQ=1 | | | | | | | | | | | | | | | | | | |
| Ingestion Pathway (µg/l) | Carc. 1E-06 | | | 0.316 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | | | | | | | | | | | 4400 | No | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 2.78 | No | | | | | | | | | | | | | | |
| Ecological Risk Scenario: | EQ=1 | | | | | | | | | | | | | | | | | | |
| Deer - Tailings Salt Ingestion (mg/Kg) | LOAEL | | | | | 880 | Yes | | | | | 314 | No | | | | | | |
| Plant Phytotoxicity - Soil (mg/Kg) | Max Phytotox. | | | 50 | No | 8 | No | 125 | No | | | 400 | No | | | | | 400 | No |
| Aquatic Life - Water (µg/l) | AALS | | | 340 | Yes | 2.1 | Yes | 14 | Yes | | | 81.6 | Yes | 1.7 | Yes | 4.1 | Unk | 120 | Yes |
| Aquatic Life - Sediment (µg/l) | PSQC | | | 85 | Yes | 9 | Yes | 390 | Yes | | | 110 | Yes | | | | | 270 | Yes |

Notes:

LOAEL - Lower observed adverse effect level

AALS - Freshwater Acute Aquatic Life Standards (DEQ, 2002). Hardness = 100 mg/l $CaCO_3$ for hardness dependent elements.

PSQC - Proposed Sediment Quality Criteria

Unk - Unknown. Cleanup goal is less than the lower detection limit.

**Table 8-2. Water Quality ARARs Attainment for Alternative 1**

| | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Drinking Water MCL/HHS | 6 | Yes | 18 | Yes | 5 | No | 1300 | Yes | 300 | Yes | 15 | Yes | 0.05 | Unk | 100 | Yes | 2000 | Yes |
| Aquatic Life CALS | | | 150 | Yes | 0.27 | Unk | 9.3 | Unk | 1000 | Yes | 3.2 | Yes | 0.91 | Yes | | | 120 | Yes |

HHS - Human Health Standards for Surface Water (DEQ, 2002)

MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories, (EPA, 1996)

CALS - Freshwater Chronic Aquatic Life Standards (DEQ, 2002)

Water concentrations in µg/L.

CALS based on water hardness of 100 mg/L.

Unk - Unknown. Cleanup goal is less than the lower detection limit.

### 8.1.2 Compliance with ARARs

A comprehensive list of federal and state Applicable or Relevant and Appropriate Requirements (ARARs) has been developed for the Buckeye Mine site and is summarized in Section 4.0. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific ARARs are waste-related requirements which specify how a waste must be managed, treated, and/or disposed depending upon the classification of the waste material. Location-specific ARARs specify how the remedial activities must take place depending upon where the wastes are physically located (i.e., in a stream or floodplain, wilderness area, or sensitive environment, etc.), or where the wastes may be treated or disposed, and what authorizations (permits) may be required. Action-specific ARARs do not determine the preferred reclamation alternative, but indicate how the selected alternative must be achieved.

Under the no action alternative, no contaminated materials would be treated, removed, or actively managed. Consequently, the no action alternative would not satisfy any federal or state contaminant-specific ARARs. Water quality ARARs are generally met for both drinking water and chronic aquatic life standards. The possible exceptions to meeting water quality ARARs are the drinking water MCL/HHS for mercury and chronic aquatic life standards for cadmium and copper, which cannot be determined because the cleanup goals are less than the lower detection limits. Water quality ARARs for surface water are listed in Table 8-2. Location and action specific ARARs are not applicable.

### 8.1.3 Long-Term Effectiveness and Permanence

Toxicity, mobility, and volume of contaminants would not be reduced under the no action alternative. Also, protection of human health and the environment would not be achieved under this alternative. No control measures would be completed on the waste sources identified as causing environmental impacts at the site. The no action alternative would not address surface water impacts that have been identified nor would it provide controls on contaminant migration via direct contact or particulate emissions.

### 8.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials.

### 8.1.5 Short-Term Effectiveness

Short-term effectiveness is not applicable.

### 8.1.6 Implementability

Technical and administrative feasibility evaluation criteria do not apply to this alternative.

### 8.1.7 Costs

No capital or operating costs would be incurred under this alternative.

## 8.2 ALTERNATIVE 4a: ON-SITE DISPOSAL IN A CONSTRUCTED RCRA REPOSITORY

The reclamation strategy for Alternative 4a involves removing the mill tailings sources from tailings piles TP-1, TP-2, TP-3, TP-4, and TP-5; waste rock sources from piles WR-1, WR-2, WR-3, WR-4, WR-5 and the gossan area; and impacted soil from the Brandon Mill area, and disposing these wastes in a constructed repository which complies with RCRA Subtitle C regulations for hazardous waste landfill closures (Figure 7-1). The only exception to the RCRA Subtitle C regulations would be the use of a GCL in place of a compacted clay liner. This is based on the site characterization results, which did not reveal the presence of a clay borrow source in the vicinity of the site. The repository would consist of a composite, double-lined leachate collection and removal system underlying the waste in conjunction with a composite, multi-layered, lined cap overlying the waste. Assuming that the tailings, waste rock and impacted soil volume was deposited in an area of approximately 1.52 acres, the total height of the repository would be approximately 45 feet, with an average waste thickness of approximately 11.6 feet, in order to achieve a 4:1 side slope design in the final cap.

The HELP model was used to simulate the RCRA Subtitle C repository scenario. Based on representative soil properties for the 1.5-foot cover soil, gravel drainage layer, 20-mil flexible membrane liner, geosynthetic clay liner (substituted for the compacted clay liner), an average of 11.6 feet of mine/mill waste, a gravel primary leachate collection/removal layer, 30-mil flexible membrane liner, a gravel secondary leachate collection/removal layer, a 30-mil flexible membrane liner and a geosynthetic clay liner (substituted for the compacted clay liner), the predicted infiltration of water through the repository base liner system is an average of 0.00000 inches per year over a 30-year period. An average of 12.146 inches of water per year is predicted to be lost through evapotranspiration, which is equivalent to 97.075 percent of the average annual precipitation of 12.51 inches. Surface water runoff accounts for a loss of 0.288 inches per year or 2.302 percent of precipitation. Lateral drainage from the geocomposite drainage layer accounts for a loss of 0.0000 inches of water per year. The remaining 0.623 percent of precipitation is accounted for by changes in water storage in the cover soil and tailings layers.

### 8.2.1 Overall Protection of Human Health and the Environment

This alternative provides control of direct exposure to the contaminated materials and reduction in risk to human health and the environment. It prevents further erosion and migration of contaminants from tailings source areas and waste rock from the Buckeye Mine site area. Existing sediment in Mill Creek is not removed in this alternative, however, existing stream sediments do not exceed cleanup goals for arsenic, cadmium, copper, lead and zinc.

Placing the wastes into a repository would prevent exposure by direct contact. It is not known if the carcinogenic risk from ingestion of arsenic via ingestion of water/fish would be reduced to 1E-06 because the cleanup goal is less than the lower detection limit. However, the carcinogenic risk from arsenic via ingestion of water/fish would be reduced to 1E-05 under the recreational risk scenario.

Soil ingestion/dust inhalation of arsenic would be reduced to below risk-based cleanup goals under the recreational risk scenario. Soil ingestion/dust inhalation of antimony, arsenic, iron, and lead would be reduced to below risk-based cleanup goals under the residential risk scenario. Carcinogenic risk from soil ingestion/dust inhalation of arsenic would not be reduced to 1E-06 under either the recreational or residential risk scenarios.

Protection of the environment would generally be achieved under this alternative. Prevention of ecological exposures via exposure to water, sediment, and soil sources would be achieved to the extent practicable: deer exposure to lead via ingestion of tailings salts; and plant phytotoxicity to arsenic, cadmium, copper, lead and zinc would achieve cleanup goals. Exposure of aquatic life to arsenic, cadmium, copper, lead and zinc via surface water; and aquatic life exposure to arsenic, cadmium, copper, lead, mercury and zinc via sediment do not currently exceed the risk-based cleanup goals. Exposure of aquatic life to silver cannot be evaluated because the risk-based cleanup goals are less than the lower detection limit. Alternative 4a would provide additional protection from future degradation of water and sediment quality by isolating the wastes in an engineered repository. A risk reduction achievement matrix for the various pathways and contaminants, identified in the baseline human health risk assessment and the ecological risk assessment is shown in Table 8-3.

### 8.2.2 Compliance with ARARs

With the exception of cadmium, contaminant-specific ARARs are expected to be met when implementing this alternative. Table 8-4 shows that the drinking water MCL for cadmium is not being met in the groundwater west of the site. Removal of the tailings piles near these wells would remove a potential source of the cadmium and may result in an improvement in groundwater quality. In addition, the drinking water MCL for mercury in groundwater west of the site and exposure of aquatic life in Mill Creek to cadmium and copper cannot be evaluated because the ARAR-based cleanup goals are less than the lower detection limit.

Implementation of this alternative is also expected to satisfy air quality regulations because the repository cap and vegetation cover would stabilize the contaminant sources and inhibit fugitive emissions. The tailings have the highest potential for fugitive emissions based on grain size.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. The tailings and waste rock materials of concern are derived from the beneficiation and extraction of ores and are therefore exempt from federal regulation under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 (b) (3) (A)(iii)(1994) as a hazardous waste. Mine and mill wastes are also excluded under the Montana Solid Waste Management Act (75-10-214 (1)(b) MCA. Any temporary stream diversions for construction activities will require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Madison County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities will be met using water sprays where applicable, i.e. excavation areas in the tailings and waste rock, and haul roads with heavy vehicular traffic.

**Table 8-3. Risk Reduction Achievement Matrix for Alternative 4a**

| Exposure Pathway | Risk Level | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Human Risk - Residential: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion | HQ=1 | | | | | | | | | | | | | | | | | | |
| Pathway (µg/l) | Carc. 1E-06 | | | 0.045 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | 31 | Yes | 23 | Yes | | | | | 23000 | Yes | 400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 0.43 | No | | | | | | | | | | | | | | |
| Human Risk - Recreational: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion/Fish | HQ=1 | | | | | | | | | | | | | | | | | | |
| Ingestion Pathway (µg/l) | Carc. 1E-06 | | | 0.316 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | | | | | | | | | | | 4400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 2.78 | No | | | | | | | | | | | | | | |
| Ecological Risk Scenario: | EQ=1 | | | | | | | | | | | | | | | | | | |
| Deer - Tailings Salt Ingestion (mg/Kg) | LOAEL | | | | | 880 | Yes | | | | | 314 | Yes | | | | | | |
| Plant Phytotoxicity - Soil (mg/Kg) | Max Phytotox. | | | 50 | Yes | 8 | Yes | 125 | Yes | | | 400 | Yes | | | | | 400 | Yes |
| Aquatic Life - Water (µg/l) | AALS | | | 340 | Yes | 2.1 | Yes | 14 | Yes | | | 81.6 | Yes | 1.7 | Yes | 4.1 | Unk | 120 | Yes |
| Aquatic Life - Sediment (µg/l) | PSQC | | | 85 | Yes | 9 | Yes | 390 | Yes | | | 110 | Yes | | | | | 270 | Yes |

Notes:

LOAEL - Lower observed adverse effect level

AALS - Freshwater Acute Aquatic Life Standards (DEQ, 2002). Hardness = 100 mg/l $CaCO_3$ for hardness dependent elements.

PSQC - Proposed Sediment Quality Criteria

Unk - Unknown. Cleanup goal is less than the lower detection limit.

**Table 8-4. Water Quality ARARs Attainment for Alternative 4a**

| | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Drinking Water MCL/HHS | 6 | Yes | 18 | Yes | 5 | No | 1300 | Yes | 300 | Yes | 15 | Yes | 0.05 | Unk | 100 | Yes | 2000 | Yes |
| Aquatic Life CALS | | | 150 | Yes | 0.27 | Unk | 9.3 | Unk | 1000 | Yes | 3.2 | Yes | 0.91 | Yes | | | 120 | Yes |

HHS - Human Health Standards for Surface Water (DEQ, 2002)

MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories, (EPA, 1996)

CALS - Freshwater Chronic Aquatic Life Standards (DEQ, 2002)

Water concentrations in ug/L.

CALS based on water hardness of 100 mg/L.

Unk - Unknown. Cleanup goal is less than the lower detection limit.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

### 8.2.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in an engineered repository. The tailings, waste rock and impacted soil would be encapsulated in an engineered repository that would effectively isolate this waste and reduce contaminant mobility. Periodic inspections and maintenance would ensure the long-term stability of the repository.

### 8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume or toxicity of the contaminants in the tailings and waste rock would not be physically nor chemically reduced. The excavation of the tailings and waste from the drainage area would reduce the contaminant mobility by moving the waste to a secure location. The primary waste sources of concern (tailings, waste rock and impacted soil) would be encapsulated in an engineered structure and physical location which is protected from erosion and water infiltration problems.

### 8.2.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities would generally be less than 90 days and should not significantly impact human health nor the environment. On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. Control of fugitive dust may require the use of water sprays. Short-term impacts to the surrounding community are expected to be minimal due to the location of the project site. The only foreseen short-term impact to the surrounding community would involve increased vehicle traffic, with associated safety hazards and dust generation, on roads in the vicinity of the waste sources and the repository. Removal of tailings and impacted soil from tailings pile TP-5 and the Brandon Mill area will require crossing Mill Creek Road to transport the wastes to the repository. A traffic control plan, including warning signs and possibly flaggers, will be required while transporting these wastes.

### 8.2.6 Implementability

This alternative is both technically and administratively feasible. Waste removal, repository construction, and establishing vegetation are readily implementable using conventional construction techniques. Key project components, such as the availability of equipment, materials, and construction expertise, are present and would aid in the timely implementation and successful execution of the proposed project.

### 8.2.7 Costs

The total present-worth cost for this alternative has been estimated at $1,062,136 which represents the removal of the tailings, selected waste rock and impacted soil to a constructed RCRA-lined repository with a leachate collection system. Table 8-5 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

The repository area was selected largely because it is one of the only areas within the patented claim block that is relatively flat. The repository site is located on the ridgeline to the north of the former Buckeye mill and headframe/ore bin and is approximately 1.52 acres. The repository site is located in an area away from surface water. An estimated 18,730 cubic yards of cover soil would be excavated from the repository area prior to waste placement and stockpiled for repository cover soil and backfill for the excavated source areas. The repository base would be lined with a geotextile cushion, GCL, 30-mil flexible membrane liner, gravel drainage layer, 30-mil flexible membrane liner, gravel drainage layer, geotextile filter fabric and leachate collection system.

The wastes would be placed in the repository in a sequence that provides the most benefit to the repository. The tailings from tailings pile TP-1 would be placed in the repository first to provide a cushion for the base liner/leachate collection system. Following the placement of waste from TP-1, the waste sources that are potentially acid generating and exceed TCLP regulatory requirements would be placed: WR-4 (including the gossan area), WR-5, TP-4, impacted sol from the Brandon Mill, TP-5 and TP-3. Waste rock from WR-1, WR-2 and WR-3 would be placed over the acid-generating and TCLP-exceeding wastes to provide a capillary barrier. Finally, tailings from TP-2 would be placed over the waste rock to provide a cushion for the top liner. The repository cap includes a geotextile cushion, GCL, 20-mil flexible membrane liner, geocomposite drainage layer and cover soil. A runon control ditch would be installed to divert water away from the repository.

After the repository construction, waste excavation, and waste placement are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level and contour the areas to match the surrounding terrain. It is assumed that soil from the repository excavation would be stockpiled and used for cover soil on the repository. Excess soil from the repository would be used as backfill/cover soil on the waste source areas. An estimated 14,990 cubic yards of cover soil would be available for backfilling the waste source areas.

The seed beds would be prepared using conventional agricultural plowing. Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas and the repository cap with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

**Table 8-5. Preliminary Cost Estimate for Alternative 4a: On-Site Disposal in a Constructed RCRA Repository**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 60,647.00 | $60,647 | 8% |
| Logistics | | | | | |
| Access Road Improvements | 1,800 | LF | 2.00 | $3,600 | |
| Temporary Bridge Installation | 1 | LS | 36,000.00 | $36,000 | |
| Site Clearing/Preparation | 6.56 | Ac | 2,000.00 | $13,120 | |
| Transformer Disposal | 1 | LS | 5,000.00 | $5,000 | |
| Mine Opening Closures (Adit/Doghole) | 1 | LS | 4,000.00 | $4,000 | |
| Debris Removal and Onsite Disposal | 1 | LS | 10,000.00 | $10,000 | |
| Repository Construction | | | | | |
| Cover Soil Removal and Stockpiling | 18,730 | CY | 2.00 | $37,460 | |
| Repository Base Grading | 1.52 | Ac | 2,000.00 | $3,040 | |
| Install Geotextile Cushion | 7,550 | SY | 3.00 | $22,650 | |
| Geosynthetic Clay Liner | 7,550 | SY | 4.50 | $33,975 | |
| Install 30 mil Flexible Membrane Liner | 7,550 | SY | 6.00 | $45,300 | |
| Gravel Drainage Layer | 2,520 | CY | 20.00 | $50,400 | |
| Install 30 mil Flexible Membrane Liner | 7,550 | SY | 6.00 | $45,300 | |
| Gravel Drainage Layer | 2,520 | CY | 20.00 | $50,400 | |
| Geotextile Filter Fabric | 7,550 | SY | 3.00 | $22,650 | |
| Leachate Collection System | 1 | LS | 10,000.00 | $10,000 | |
| Waste Load, Haul & Dump | | | | | |
| TP-1 | 4,000 | CY | 3.50 | $14,000 | |
| WR-4 | 3,730 | CY | 3.50 | $13,055 | |
| Gossan Area | 160 | CY | 4.00 | $640 | |
| WR-5 | 2,280 | CY | 5.00 | $11,400 | |
| TP-4 | 3,170 | CY | 5.00 | $15,850 | |
| Brandon Mill Impacted Soil | 2,750 | CY | 5.00 | $13,750 | |
| TP-5 | 900 | CY | 5.00 | $4,500 | |
| TP-3 | 3,150 | CY | 3.50 | $11,025 | |
| WR-2 | 1,269 | CY | 5.00 | $6,345 | |
| WR-1 | 180 | CY | 5.00 | $900 | |
| WR-3 | 220 | CY | 5.00 | $1,100 | |
| TP-2 | 2,260 | CY | 3.50 | $7,910 | |
| Waste Grading and Compaction | 24,069 | CY | 2.00 | $48,138 | |
| Repository Cap Construction | | | | | |
| Install Geotextile Cushion | 7,480 | SY | 3.00 | $22,440 | |
| Geosynthetic Clay Liner | 7,480 | SY | 4.50 | $33,660 | |
| Install 20 mil Flexible Membrane Liner | 7,480 | SY | 5.00 | $37,400 | |
| Geocomposite Drainage Layer | 7,480 | SY | 4.50 | $33,660 | |
| Cover Soil | 3,740 | CY | 2.00 | $7,480 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 200 | LF | 4.00 | $800 | |
| Backfill and Grade Waste Source Areas | 14,990 | CY | 4.50 | $67,455 | |
| Revegetation | | | | | |
| Seed/Fertilize | 8.10 | Ac | 1,000.00 | $8,100 | |
| Mulch | 8.10 | Ac | 1,000.00 | $8,100 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,040 | LF | 3.00 | $15,120 | |
| Repository Fence | 1,260 | LF | 6.00 | $7,560 | |
| Temporary Bridge Salvage (70%) | -70% | LS | 36,000.00 | ($25,200) | |
| Subtotal | | | | $818,730 | |
| Construction Oversight | 15% | | | $122,810 | |
| Subtotal Capital Costs | | | | $941,540 | |
| Contingency | 10% | | | $94,154 | |
| TOTAL CAPITAL COSTS | | | | $1,035,693 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $1,035,693 | |
| PRESENT WORTH O&M COST | 30 yrs @ | | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $1,062,136 | |

A runon/runoff control ditch would be constructed in the area of the repository to divert runoff away from the repository cap. Barbed-wire fencing would be placed around the excavated waste source areas to allow the establishment of vegetation without interference from livestock. A woven-wire fence would be constructed around the repository to limit access.

Other ancillary tasks that would be completed include removal and disposal of an electrical transformer near the former Buckeye mill area, closure of two mine openings and removal and disposal of debris. It is not known whether the transformer contains polychlorinated biphenols (PCBs). Disposal of the transformer must include sampling and analysis to determine the appropriate method of disposal. The mine openings that require closure include the adit located approximately 200 feet northeast of waste rock pile WR-5 and an open dog hole located near the gossan outcrop area.

The general construction steps for implementing Alternative 4a are as follows:

- improving access roads from the waste source areas to the repository;
- installation of a temporary bridge across Mill Creek to allow access to the repository (as an alternative, wastes from TP-4, TP-5 and the Brandon Mill can be hauled down Mill Creek Road to the existing access road to the upper portion of the site);
- site clearing, preparation and debris removal;
- testing, removal and disposal of an electrical transformer;
- closure of an adit and doghole;
- preparation of the repository base, including vegetation, rock and debris removal, and recovery and stockpiling of cover soil;
- placement of the repository base liner and leachate collection system;
- excavation, loading, hauling, placement, grading and compaction of tailings, waste rock and impacted soil in the following order: TP-1, WR-4/gossan area, WR-5, TP-4, BM, TP-5, TP-3, WR-2, WR-1, WR-3 and TP-2;
- installation of the cap liners and geocomposite drainage layer;
- placement and grading of stockpiled cover soil on the repository;
- constructing surface water diversion ditches strategically located to control water runon in the vicinity of the repository;
- backfilling and grading of excavated source areas with remaining stockpiled borrow soil;
- establishing vegetation on the repository, excavated waste and impacted soil areas, borrow soil stockpile area and haul roads by seeding, fertilizing and mulching;
- constructing a 4-strand, barbed-wire fence around the perimeter of the excavated source areas; and

- construction of a woven-wire fence around the repository.

## 8.3 ALTERNATIVE 4b: ON-SITE DISPOSAL IN A CONSTRUCTED MODIFIED RCRA REPOSITORY

The reclamation strategy for Alternative 4b involves removing the mill tailings sources from tailings piles TP-1, TP-2, TP-3, TP-4, and TP-5; waste rock sources from piles WR-1, WR-2, WR-3, WR-4, WR-5 and the gossan area; and impacted soil from the Brandon Mill area, and disposing these wastes in a constructed modified RCRA repository which includes a single GCL base liner (without a leachate collection and removal system) and a multi-layered cap. The repository would consist of a geosynthetic clay liner underlying the waste in conjunction with a composite, multi-layered, lined cap overlying the waste. Assuming that the tailings, waste rock and impacted soil volume was deposited in an area of approximately 1.52 acres, the total height of the repository would be approximately 45 feet, with an average waste thickness of approximately 11.6 feet, in order to achieve a 4:1 side slope design in the final cap.

The HELP model was used to simulate the modified RCRA repository scenario. Based on representative soil properties for the 1.5-foot cover soil, geocomposite drainage layer, geosynthetic clay liner, an average of 11.6 feet of mine/mill waste and a base geosynthetic clay liner, the predicted infiltration of water through the repository base liner system is an average of 0.00000 inches per year over a 30-year period. An average of 12.146 inches of water per year is predicted to be lost through evapotranspiration, which is equivalent to 97.075 percent of the average annual precipitation of 12.51 inches. Surface water runoff accounts for a loss of 0.288 inches per year or 2.302 percent of precipitation. Lateral drainage from the geocomposite drainage layer accounts for a loss of 0.0000 inches of water per year. The remaining 0.623 percent of precipitation is accounted for by changes in water storage in the cover soil and tailings layers.

### 8.3.1 Overall Protection of Human Health and the Environment

This alternative provides control of direct exposure to the contaminated materials and reduction in risk to human health and the environment. It prevents further erosion and migration of contaminants from tailings source areas and waste rock from the Buckeye Mine site area. Existing sediment in Mill Creek is not removed in this alternative, however, existing stream sediments do not exceed cleanup goals for arsenic, cadmium, copper, lead and zinc.

Placing the wastes into a repository would prevent exposure by direct contact. It is not know if the carcinogenic risk from ingestion of arsenic via ingestion of water/fish would be reduced to 1E-06 because the cleanup goal is less than the lower detection limit. However, the carcinogenic risk from arsenic via ingestion of water/fish would be reduced to 1E-05 under the recreational risk scenario.

Soil ingestion/dust inhalation of arsenic would be reduced to below risk-based cleanup goals under the recreational risk scenario. Soil ingestion/dust inhalation of antimony, arsenic, iron, and lead would be reduced to below risk-based cleanup goals under the residential risk scenario. Carcinogenic risk from soil ingestion/dust inhalation of arsenic would not be reduced to 1E-06 under either the recreational or residential risk scenarios.

Protection of the environment would generally be achieved under this alternative. Prevention of ecological exposures via exposure to water, sediment, and soil sources would be achieved to the extent practicable: deer exposure to lead via ingestion of tailings salts; and plant phytotoxicity to arsenic, cadmium, copper, lead and zinc would achieve cleanup goals. Acute exposure of aquatic life to arsenic, cadmium, copper, lead and zinc via surface water; and aquatic life exposure to arsenic, cadmium, copper, lead, mercury and zinc via sediment do not currently exceed the risk-based cleanup goals. Acute exposure of aquatic life to silver cannot be evaluated because the risk-based cleanup goals are less than the lower detection limit. Alternative 4b would provide additional protection from future degradation of water and sediment quality by isolating the wastes in an engineered repository. A risk reduction achievement matrix for the various pathways and contaminants, identified in the baseline human health risk assessment and the ecological risk assessment is shown in Table 8-6.

### 8.3.2 Compliance with ARARs

With the exception of cadmium, contaminant-specific ARARs are expected to be met when implementing this alternative. Table 8-7 shows that the drinking water MCL for cadmium is not being met in the groundwater west of the site. Removal of the tailings piles near these wells would remove a potential source of the cadmium and may result in an improvement in groundwater quality. In addition, the drinking water MCL for mercury in groundwater west of the site and exposure of aquatic life in Mill Creek to cadmium and copper cannot be evaluated because the ARAR-based cleanup goals are less than the lower detection limit.

Implementation of this alternative is also expected to satisfy air quality regulations because the repository cap and vegetation cover would stabilize the contaminant sources and inhibit fugitive emissions. The tailings have the highest potential for fugitive emissions based on grain size.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. The tailings and waste rock materials of concern are derived from the beneficiation and extraction of ores and are therefore exempt from federal regulation under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 (b) (3) (A)(iii)(1994) as a hazardous waste. Mine and mill wastes are also excluded under the Montana Solid Waste Management Act (75-10-214 (1)(b) MCA. Any temporary stream diversions for construction activities will require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Madison County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities will be met using water sprays where applicable, i.e. excavation areas in the tailings and waste rock, and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations

**Table 8-6. Risk Reduction Achievement Matrix for Alternative 4b**

| Exposure Pathway | Risk Level | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Human Risk - Residential: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion | HQ=1 | | | | | | | | | | | | | | | | | | |
| Pathway (µg/l) | Carc. 1E-06 | | | 0.045 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | 31 | Yes | 23 | Yes | | | | | 23000 | Yes | 400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 0.43 | No | | | | | | | | | | | | | | |
| Human Risk - Recreational: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion/Fish | HQ=1 | | | | | | | | | | | | | | | | | | |
| Ingestion Pathway (µg/l) | Carc. 1E-06 | | | 0.316 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | | | | | | | | | | | 4400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 2.78 | No | | | | | | | | | | | | | | |
| Ecological Risk Scenario: | EQ=1 | | | | | | | | | | | | | | | | | | |
| Deer - Tailings Salt Ingestion (mg/Kg) | LOAEL | | | | | 880 | Yes | | | | | 314 | Yes | | | | | | |
| Plant Phytotoxicity - Soil (mg/Kg) | Max Phytotox. | | | 50 | Yes | 8 | Yes | 125 | Yes | | | 400 | Yes | | | | | 400 | Yes |
| Aquatic Life - Water (µg/l) | AALS | | | 340 | Yes | 2.1 | Yes | 14 | Yes | | | 81.6 | Yes | 1.7 | Yes | 4.1 | Unk | 120 | Yes |
| Aquatic Life - Sediment (µg/l) | PSQC | | | 85 | Yes | 9 | Yes | 390 | Yes | | | 110 | Yes | | | | | 270 | Yes |

Notes:

LOAEL - Lower observed adverse effect level

AALS - Freshwater Acute Aquatic Life Standards (DEQ, 2002). Hardness = 100 mg/l $CaCO_3$ for hardness dependent elements.

PSQC - Proposed Sediment Quality Criteria

Unk - Unknown. Cleanup goal is less than the lower detection limit.

**Table 8-7. Water Quality ARARs Attainment for Alternative 4b**

| | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Drinking Water MCL/HHS | 6 | Yes | 18 | Yes | 5 | No | 1300 | Yes | 300 | Yes | 15 | Yes | 0.05 | Unk | 100 | Yes | 2000 | Yes |
| Aquatic Life CALS | | | 150 | Yes | 0.27 | Unk | 9.3 | Unk | 1000 | Yes | 3.2 | Yes | 0.91 | Yes | | | 120 | Yes |

HHS - Human Health Standards for Surface Water (DEQ, 2002)

MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories, (EPA, 1996)

CALS - Freshwater Chronic Aquatic Life Standards (DEQ, 2002)

Water concentrations in ug/L.

CALS based on water hardness of 100 mg/L.

Unk - Unknown. Cleanup goal is less than the lower detection limit.

and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

### 8.3.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in an engineered repository. The tailings, waste rock and impacted soil would be encapsulated in an engineered repository that would effectively isolate this waste and reduce contaminant mobility. Periodic inspections and maintenance would ensure the long-term stability of the repository.

### 8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume or toxicity of the contaminants in the tailings and waste rock would not be physically nor chemically reduced. The excavation of the tailings and waste from the drainage area would reduce the contaminant mobility by moving the waste to a secure location. The primary waste sources of concern (tailings and waste rock piles) would be encapsulated in an engineered structure and physical location which is protected from erosion and water infiltration problems.

### 8.3.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities would generally be less than 90 days and should not significantly impact human health nor the environment. On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. Control of fugitive dust may require the use of water sprays. Short-term impacts to the surrounding community are expected to be minimal due to the location of the project site. The only foreseen short-term impact to the surrounding community would involve increased vehicle traffic, with associated safety hazards and dust generation, on roads in the vicinity of the waste sources and the repository. Removal of tailings and impacted soil from tailings pile TP-5 and the Brandon Mill area will require crossing Mill Creek Road to transport the wastes to the repository. A traffic control plan, including warning signs and possibly flaggers, will be required while transporting these wastes.

### 8.3.6 Implementability

This alternative is both technically and administratively feasible. Waste removal, repository construction, and establishing vegetation are readily implementable using conventional construction techniques. Key project components, such as the availability of equipment, materials, and construction expertise, are present and would aid in the timely implementation and successful execution of the proposed project.

### 8.3.7 Costs

The total present-worth cost for this alternative has been estimated at $704,943 which represents the removal of the tailings, waste rock and impacted soil to a constructed modified RCRA repository. Table 8-8 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

The repository area was selected largely because it is one of the only areas within the patented claim block that is relatively flat. The repository site is located on the ridgeline to the north of the former Buckeye mill and headframe/ore bin and is approximately 1.52 acres. The repository site is located in an area away from surface water. An estimated 18,730 cubic yards of cover soil would be excavated from the repository area prior to waste placement and stockpiled for repository cover soil and backfill for the excavated source areas. The repository base would be lined with a geotextile cushion and a GCL.

The wastes would be placed in the repository in a sequence that provides the most benefit to the repository. The tailings from tailings pile TP-1 would be placed in the repository first to provide a cushion for the base liner/leachate collection system. Following the placement of waste from TP-1, the waste sources that are potentially acid generating and exceed TCLP regulatory requirements would be placed: WR-4 (including the gossan area), WR-5, TP-4, impacted sol from the Brandon Mill, TP-5 and TP-3. Waste rock from WR-1, WR-2 and WR-3 would be placed over the acid-generating and TCLP-exceeding wastes to provide a capillary barrier. Finally, tailings from TP-2 would be placed over the waste rock to provide a cushion for the top liner. The repository cap includes a geotextile cushion, GCL, geocomposite drainage layer and cover soil. A runon control ditch would be installed to divert water away from the repository.

After the repository construction, waste excavation, and waste placement are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level and contour the areas to match the surrounding terrain. It is assumed that soil from the repository excavation would be stockpiled and used for cover soil on the repository. Excess soil from the repository would be used as backfill/cover soil on the waste source areas. An estimated 14,990 cubic yards of cover soil would be available for backfilling the waste source areas.

The seed beds would be prepared using conventional agricultural plowing. Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas and the repository cap with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism. A runon/runoff control ditch would be constructed in the area of the repository to divert runoff away from the repository cap. Barbed-wire fencing would be placed around the excavated waste source areas to allow the establishment of vegetation without interference from livestock. A woven-wire fence would be constructed around the repository to limit access.

**Table 8-8. Preliminary Cost Estimate for Alternative 4b: On-Site Disposal in a Constructed Modified RCRA Repository**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 39,731.00 | $39,731 | 8% |
| Logistics | | | | | |
| Access Road Improvements | 1,800 | LF | 2.00 | $3,600 | |
| Temporary Bridge Installation | 1 | LS | 36,000.00 | $36,000 | |
| Site Clearing/Preparation | 6.56 | Ac | 2,000.00 | $13,120 | |
| Transformer Disposal | 1 | LS | 5,000.00 | $5,000 | |
| Mine Opening Closures (Adit/Doghole) | 1 | LS | 4,000.00 | $4,000 | |
| Debris Removal and Onsite Disposal | 1 | LS | 10,000.00 | $10,000 | |
| Repository Construction | | | | | |
| Cover Soil Removal and Stockpiling | 18,730 | CY | 2.00 | $37,460 | |
| Repository Base Grading | 1.52 | Ac | 2,000.00 | $3,040 | |
| Install Geotextile Cushion | 7,550 | SY | 3.00 | $22,650 | |
| Geosynthetic Clay Liner | 7,550 | SY | 4.50 | $33,975 | |
| Waste Load, Haul & Dump | | | | | |
| TP-1 | 4,000 | CY | 3.50 | $14,000 | |
| WR-4 | 3,730 | CY | 3.50 | $13,055 | |
| Gossan Area | 160 | CY | 4.00 | $640 | |
| WR-5 | 2,280 | CY | 5.00 | $11,400 | |
| TP-4 | 3,170 | CY | 5.00 | $15,850 | |
| Brandon Mill Impacted Soil | 2,750 | CY | 5.00 | $13,750 | |
| TP-5 | 900 | CY | 5.00 | $4,500 | |
| TP-3 | 3,150 | CY | 3.50 | $11,025 | |
| WR-2 | 1,269 | CY | 5.00 | $6,345 | |
| WR-1 | 180 | CY | 5.00 | $900 | |
| WR-3 | 220 | CY | 5.00 | $1,100 | |
| TP-2 | 2,260 | CY | 3.50 | $7,910 | |
| Waste Grading and Compaction | 24,069 | CY | 2.00 | $48,138 | |
| Repository Cap Construction | | | | | |
| Install Geotextile Cushion | 7,480 | SY | 3.00 | $22,440 | |
| Geosynthetic Clay Liner | 7,480 | SY | 4.50 | $33,660 | |
| Geocomposite Drainage Layer | 7,480 | SY | 4.50 | $33,660 | |
| Cover Soil | 3,740 | CY | 2.00 | $7,480 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 200 | LF | 4.00 | $800 | |
| Backfill and Grade Waste Source Areas | 14,990 | CY | 4.50 | $67,455 | |
| Revegetation | | | | | |
| Seed/Fertilize | 8.10 | Ac | 1,000.00 | $8,100 | |
| Mulch | 8.10 | Ac | 1,000.00 | $8,100 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,040 | LF | 3.00 | $15,120 | |
| Repository Fence | 1,260 | LF | 6.00 | $7,560 | |
| Temporary Bridge Salvage (70%) | -70% | LS | 36,000.00 | ($25,200) | |
| Subtotal | | | | $536,364 | |
| Construction Oversight | 15% | | | $80,455 | |
| Subtotal Capital Costs | | | | $616,819 | |
| Contingency | 10% | | | $61,682 | |
| TOTAL CAPITAL COSTS | | | | $678,500 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $678,500 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $704,943 | |

Other ancillary tasks that would be completed include removal and disposal of an electrical transformer near the former Buckeye mill area, closure of two mine openings and removal and disposal of debris. It is not known whether the transformer contains polychlorinated biphenols (PCBs). Disposal of the transformer must include sampling and analysis to determine the appropriate method of disposal. The mine openings that require closure include the adit located approximately 200 feet northeast of waste rock pile WR-5 and an open dog hole located near the gossan outcrop area.

The general construction steps for implementing Alternative 4b are as follows:

- improving access roads from the waste source areas to the repository;
- installation of a temporary bridge across Mill Creek to allow access to the repository (as an alternative, wastes from TP-4, TP-5 and the Brandon Mill can be hauled down Mill Creek Road to the existing access road to the upper portion of the site);
- site clearing, preparation and debris removal;
- removal and disposal of an electrical transformer;
- closure of an adit and doghole;
- preparation of the repository base, including vegetation, rock and debris removal, and recovery and stockpiling of cover soil;
- placement of the repository base liner;
- excavation, loading, hauling, placement, grading and compaction of tailings, waste rock and impacted soil in the following order: TP-1, WR-4/gossan area, WR-5, TP-4, BM, TP-5, TP-3, WR-2, WR-1, WR-3 and TP-2;
- installation of the cap liners and geocomposite drainage layer;
- placement and grading of stockpiled cover soil on the repository;
- constructing surface water diversion ditches strategically located to control water runon in the vicinity of the repository;
- backfilling and grading of excavated source areas with remaining stockpiled borrow soil;
- establishing vegetation on the repository, excavated waste and impacted soil areas, borrow soil stockpile area and haul roads by seeding, fertilizing and mulching;
- constructing a 4-strand, barbed-wire fence around the perimeter of the excavated source areas; and
- construction of a woven-wire fence around the repository.

## 8.4 ALTERNATIVE 4c: ON-SITE DISPOSAL IN A CONSTRUCTED UNLINED REPOSITORY WITH A MULTI-LAYERED CAP

The reclamation strategy for Alternative 4c involves removing the mill tailings sources from tailings piles TP-1, TP-2, TP-3, TP-4, and TP-5; waste rock sources from piles WR-1, WR-2, WR-3, WR-4, WR-5 and the gossan area; and impacted soil from the Brandon Mill area, and disposing these wastes in a constructed unlined repository with a multi-layered cap. The repository would consist of a composite, multi-layered, lined cap overlying the waste. Assuming that the tailings, waste rock and impacted soil volume was deposited in an area of approximately 1.52 acres, the total height of the repository would be approximately 45 feet, with an average waste thickness of approximately 11.6 feet, in order to achieve a 4:1 side slope design in the final cap.

The HELP model was used to simulate the unlined repository with a multi-layered cap scenario. Based on representative soil properties for the 1.5-foot cover soil, geocomposite drainage layer, geosynthetic clay liner, and an average of 11.6 feet of mine/mill waste, the predicted infiltration of water through the tailings is an average of 0.00000 inches per year over a 30-year period. An average of 12.146 inches of water per year is predicted to be lost through evapotranspiration, which is equivalent to 97.075 percent of the average annual precipitation of 12.51 inches. Surface water runoff accounts for a loss of 0.288 inches per year or 2.302 percent of precipitation. Lateral drainage from the geocomposite drainage layer accounts for a loss of 0.0000 inches of water per year. The remaining 0.623 percent of precipitation is accounted for by changes in water storage in the cover soil and tailings layers.

### 8.4.1 Overall Protection of Human Health and the Environment

This alternative provides control of direct exposure to the contaminated materials and reduction in risk to human health and the environment. It prevents further erosion and migration of contaminants from tailings source areas and waste rock from the Buckeye Mine site area. Existing sediment in Mill Creek is not removed in this alternative, however, existing stream sediments do not exceed cleanup goals for arsenic, cadmium, copper, lead and zinc.

Placing the wastes into a repository would prevent exposure by direct contact. It is not known if the carcinogenic risk from ingestion of arsenic via ingestion of water/fish would be reduced to 1E-06 because the cleanup goal is less than the lower detection limit. However, the carcinogenic risk from arsenic via ingestion of water/fish would be reduced to 1E-05 under the recreational risk scenario.

Soil ingestion/dust inhalation of arsenic would be reduced to below risk-based cleanup goals under the recreational risk scenario. Soil ingestion/dust inhalation of antimony, arsenic, iron, and lead would be reduced to below risk-based cleanup goals under the residential risk scenario. Carcinogenic risk from soil ingestion/dust inhalation of arsenic would not be reduced to 1E-06 under either the recreational or residential risk scenarios.

Protection of the environment would generally be achieved under this alternative. Prevention of ecological exposures via exposure to water, sediment, and soil sources would be achieved to the extent practicable: deer exposure to lead via ingestion of tailings salts; and plant phytotoxicity to arsenic, cadmium, copper, lead and zinc would achieve cleanup goals. Acute exposure of aquatic life to arsenic, cadmium, copper, lead and zinc via surface water; and aquatic life exposure to arsenic, cadmium, copper, lead, mercury and zinc via sediment do not currently exceed the risk-based cleanup goals. Acute exposure of aquatic life to silver cannot be evaluated because the risk-based cleanup goals are less than the lower detection limit. Alternative 4b would provide additional protection from future degradation of water and sediment quality by isolating the wastes in an engineered repository. A risk reduction achievement matrix for the various pathways and contaminants, identified in the baseline human health risk assessment and the ecological risk assessment is shown in Table 8-9.

### 8.4.2 Compliance with ARARs

With the exception of cadmium, contaminant-specific ARARs are expected to be met when implementing this alternative. Table 8-10 shows that the drinking water MCL for cadmium is not being met in the groundwater west of the site. Removal of the tailings piles near these wells would remove a potential source of the cadmium and may result in an improvement in groundwater quality. In addition, the drinking water MCL for mercury in groundwater west of the site and exposure of aquatic life in Mill Creek to cadmium and copper cannot be evaluated because the ARAR-based cleanup goals are less than the lower detection limit.

Implementation of this alternative is also expected to satisfy air quality regulations because the repository cap and vegetation cover would stabilize the contaminant sources and inhibit fugitive emissions. The tailings have the highest potential for fugitive emissions based on grain size.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. The tailings and waste rock materials of concern are derived from the beneficiation and extraction of ores and are therefore exempt from federal regulation under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 (b) (3) (A)(iii)(1994) as a hazardous waste. Mine and mill wastes are also excluded under the Montana Solid Waste Management Act (75-10-214 (1)(b) MCA. Any temporary stream diversions for construction activities will require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Madison County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities will be met using water sprays where applicable, i.e. excavation areas in the tailings and waste rock, and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

**Table 8-9. Risk Reduction Achievement Matrix for Alternative 4c**

| Exposure Pathway | Risk Level | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Human Risk - Residential: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion | HQ=1 | | | | | | | | | | | | | | | | | | |
| Pathway (µg/l) | Carc. 1E-06 | | | 0.045 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | 31 | Yes | 23 | Yes | | | | | 23000 | Yes | 400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 0.43 | No | | | | | | | | | | | | | | |
| Human Risk - Recreational: | | | | | | | | | | | | | | | | | | | |
| Water Ingestion/Fish | HQ=1 | | | | | | | | | | | | | | | | | | |
| Ingestion Pathway (µg/l) | Carc. 1E-06 | | | 0.316 | Unk | | | | | | | | | | | | | | |
| Soil Ingestion/Dust | HQ=1 | | | | | | | | | | | 4400 | Yes | | | | | | |
| Inhalation Pathway (mg/Kg) | Carc. 1E-06 | | | 2.78 | No | | | | | | | | | | | | | | |
| Ecological Risk Scenario: | EQ=1 | | | | | | | | | | | | | | | | | | |
| Deer - Tailings Salt Ingestion (mg/Kg) | LOAEL | | | | | 880 | Yes | | | | | 314 | Yes | | | | | | |
| Plant Phytotoxicity - Soil (mg/Kg) | Max Phytotox. | | | 50 | Yes | 8 | Yes | 125 | Yes | | | 400 | Yes | | | | | 400 | Yes |
| Aquatic Life - Water (µg/l) | AALS | | | 340 | Yes | 2.1 | Yes | 14 | Yes | | | 81.6 | Yes | 1.7 | Yes | 4.1 | Unk | 120 | Yes |
| Aquatic Life - Sediment (µg/l) | PSQC | | | 85 | Yes | 9 | Yes | 390 | Yes | | | 110 | Yes | | | | | 270 | Yes |

Notes:

LOAEL - Lower observed adverse effect level

AALS - Freshwater Acute Aquatic Life Standards (DEQ, 2002). Hardness = 100 mg/l $CaCO_3$ for hardness dependent elements.

PSQC - Proposed Sediment Quality Criteria

Unk - Unknown. Cleanup goal is less than the lower detection limit.

**Table 8-10. Water Quality ARARs Attainment for Alternative 4c**

| | Antimony | | Arsenic | | Cadmium | | Copper | | Iron | | Lead | | Mercury | | Silver | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal | Cleanup Goal | Achieve Goal |
| Drinking Water MCL/HHS | 6 | Yes | 18 | Yes | 5 | No | 1300 | Yes | 300 | Yes | 15 | Yes | 0.05 | Unk | 100 | Yes | 2000 | Yes |
| Aquatic Life CALS | | | 150 | Yes | 0.27 | Unk | 9.3 | Unk | 1000 | Yes | 3.2 | Yes | 0.91 | Yes | | | 120 | Yes |

HHS - Human Health Standards for Surface Water (DEQ, 2002)

MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories, (EPA, 1996)

CALS - Freshwater Chronic Aquatic Life Standards (DEQ, 2002)

Water concentrations in µg/L.

CALS based on water hardness of 100 mg/L.

Unk - Unknown. Cleanup goal is less than the lower detection limit.

### 8.4.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in an engineered repository. The tailings, waste rock and impacted soil would be encapsulated in an engineered repository that would effectively isolate this waste and reduce contaminant mobility. Periodic inspections and maintenance would ensure the long-term stability of the repository.

### 8.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume or toxicity of the contaminants in the tailings and waste rock would not be physically nor chemically reduced. The excavation of the tailings and waste from the drainage area would reduce the contaminant mobility by moving the waste to a secure location. The primary waste sources of concern (tailings, waste rock and impacted soil) would be encapsulated in an engineered structure and physical location which is protected from erosion and water infiltration problems.

### 8.4.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities would generally be less than 90 days and should not significantly impact human health nor the environment. On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. Control of fugitive dust may require the use of water sprays. Short-term impacts to the surrounding community are expected to be minimal due to the location of the project site. The only foreseen short-term impact to the surrounding community would involve increased vehicle traffic, with associated safety hazards and dust generation, on roads in the vicinity of the waste sources and the repository. Removal of tailings and impacted soil from tailings pile TP-5 and the Brandon Mill area will require crossing Mill Creek Road to transport the wastes to the repository. A traffic control plan, including warning signs and possibly flaggers, will be required while transporting these wastes.

### 8.4.6 Implementability

This alternative is both technically and administratively feasible. Waste removal, repository construction, and establishing vegetation are readily implementable using conventional construction techniques. Key project components, such as the availability of equipment, materials, and construction expertise, are present and would aid in the timely implementation and successful execution of the proposed project.

### 8.4.7 Costs

The total present-worth cost for this alternative has been estimated at $627,582 which represents the removal of the tailings, selected waste rock and impacted soil to a constructed unlined repository with a multi-layered cap. Table 8-11 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

The repository area was selected largely because it is one of the only areas within the patented claim block that is relatively flat. The repository site is located on the ridgeline to the north of the former Buckeye mill and headframe/ore bin and is approximately 1.52 acres. The repository site is located in an area away from surface water. An estimated 18,730 cubic yards of cover soil would be excavated from the repository area prior to waste placement and stockpiled for repository cover soil and backfill for the excavated source areas. The repository base would be unlined.

The wastes would be placed in the repository in a sequence that provides the most benefit to the repository. The tailings from tailings pile TP-1 would be placed in the repository first to provide a cushion for the base liner/leachate collection system. Following the placement of waste from TP-1, the waste sources that are potentially acid generating and exceed TCLP regulatory requirements would be placed: WR-4 (including the gossan area), WR-5, TP-4, impacted sol from the Brandon Mill, TP-5 and TP-3. Waste rock from WR-1, WR-2 and WR-3 would be placed over the acid-generating and TCLP-exceeding wastes to provide a capillary barrier. Finally, tailings from TP-2 would be placed over the waste rock to provide a cushion for the top liner. The repository cap includes a geotextile cushion, GCL, geocomposite drainage layer and cover soil. A runon control ditch would be installed to divert water away from the repository.

After the repository construction, waste excavation, and waste placement are complete, the excavated areas would be revegetated. Cover/fill soil may be required in the excavated areas to level and contour the areas to match the surrounding terrain. It is assumed that soil from the repository excavation would be stockpiled and used for cover soil on the repository. Excess soil from the repository would be used as backfill/cover soil on the waste source areas. An estimated 14,990 cubic yards of cover soil would be available for backfilling the waste source areas.

The seed beds would be prepared using conventional agricultural plowing. Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill and hydroseeding application. Mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas and the repository cap with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism. A runon/runoff control ditch would be constructed in the area of the repository to divert runoff away from the repository cap. Barbed-wire fencing would be placed around the excavated waste source areas to allow the establishment of vegetation without interference from livestock. A woven-wire fence would be constructed around the repository to limit access.

**Table 8-11. Preliminary Cost Estimate for Alternative 4c: On-Site Disposal in a Constructed Unlined Repository with a Multi-Layered Cap**

| Task | Quantity | Units | Unit $ | Cost $ | Comment |
|---|---|---|---|---|---|
| Mobilization, Bonding & Insurance | 1 | L.S. | 35,201.00 | $35,201 | 8% |
| Logistics | | | | | |
| Access Road Improvements | 1,800 | LF | 2.00 | $3,600 | |
| Temporary Bridge Installation | 1 | LS | 36,000.00 | $36,000 | |
| Site Clearing/Preparation | 6.56 | Ac | 2,000.00 | $13,120 | |
| Transformer Disposal | 1 | LS | 5,000.00 | $5,000 | |
| Mine Opening Closures (Adit/Doghole) | 1 | LS | 4,000.00 | $4,000 | |
| Debris Removal and Onsite Disposal | 1 | LS | 10,000.00 | $10,000 | |
| Repository Construction | | | | | |
| Cover Soil Removal and Stockpiling | 18,730 | CY | 2.00 | $37,460 | |
| Repository Base Grading | 1.52 | Ac | 2,000.00 | $3,040 | |
| Waste Load, Haul & Dump | | | | | |
| TP-1 | 4,000 | CY | 3.50 | $14,000 | |
| WR-4 | 3,730 | CY | 3.50 | $13,055 | |
| Gossan Area | 160 | CY | 4.00 | $640 | |
| WR-5 | 2,280 | CY | 5.00 | $11,400 | |
| TP-4 | 3,170 | CY | 5.00 | $15,850 | |
| Brandon Mill Impacted Soil | 2,750 | CY | 5.00 | $13,750 | |
| TP-5 | 900 | CY | 5.00 | $4,500 | |
| TP-3 | 3,150 | CY | 3.50 | $11,025 | |
| WR-2 | 1,269 | CY | 5.00 | $6,345 | |
| WR-1 | 180 | CY | 5.00 | $900 | |
| WR-3 | 220 | CY | 5.00 | $1,100 | |
| TP-2 | 2,260 | CY | 3.50 | $7,910 | |
| Waste Grading and Compaction | 24,069 | CY | 2.00 | $48,138 | |
| Repository Cap Construction | | | | | |
| Install Geotextile Cushion | 7,480 | SY | 3.00 | $22,440 | |
| Geosynthetic Clay Liner | 7,480 | SY | 4.50 | $33,660 | |
| Geocomposite Drainage Layer | 7,480 | SY | 4.50 | $33,660 | |
| Cover Soil | 3,740 | CY | 2.00 | $7,480 | |
| Water Diversion/Runon Controls | | | | | |
| Run-on Control Ditch | 200 | LF | 4.00 | $800 | |
| Backfill and Grade Waste Source Areas | 14,990 | CY | 4.50 | $67,455 | |
| Revegetation | | | | | |
| Seed/Fertilize | 8.10 | Ac | 1,000.00 | $8,100 | |
| Mulch | 8.10 | Ac | 1,000.00 | $8,100 | |
| Fencing | | | | | |
| Barbed-wire Fence | 5,040 | LF | 3.00 | $15,120 | |
| Repository Fence | 1,260 | LF | 6.00 | $7,560 | |
| Temporary Bridge Salvage (70%) | -70% | LS | 36,000.00 | ($25,200) | |
| Subtotal | | | | $475,209 | |
| Construction Oversight | 15% | | | $71,281 | |
| Subtotal Capital Costs | | | | $546,490 | |
| Contingency | 10% | | | $54,649 | |
| TOTAL CAPITAL COSTS | | | | $601,139 | |
| POST CLOSURE MONITORING AND MAINTENANCE COSTS | | | | | |
| Inspections | 1 | /Year | 250 | $250 | |
| Sampling & Analysis | 4 | /Year | 200 | $800 | |
| Maintenance | 1 | L.S. | 1500 | $1,500 | |
| Subtotal | | | | $2,550 | |
| Contingency | 10% | | | $255 | |
| TOTAL ANNUAL O&M COST | | | | $2,805 | |
| TOTAL CAPITAL COSTS | | | | $601,139 | |
| PRESENT WORTH O&M COST | 30 | yrs @ | 10% | $26,442 | |
| **TOTAL PRESENT WORTH COST** | | | | $627,582 | |

Other ancillary tasks that would be completed include removal and disposal of an electrical transformer near the former Buckeye mill area, closure of two mine openings and removal and disposal of debris. It is not known whether the transformer contains polychlorinated biphenols (PCBs). Disposal of the transformer must include sampling and analysis to determine the appropriate method of disposal. The mine openings that require closure include the adit located approximately 200 feet northeast of waste rock pile WR-5 and an open dog hole located near the gossan outcrop area.

The general construction steps for implementing Alternative 4c are as follows:

- improving access roads from the waste source areas to the repository;
- installation of a temporary bridge across Mill Creek to allow access to the repository (as an alternative, wastes from TP-4, TP-5 and the Brandon Mill can be hauled down Mill Creek Road to the existing access road to the upper portion of the site);
- site clearing, preparation and debris removal;
- removal and disposal of an electrical transformer;
- closure of an adit and doghole;
- preparation of the repository base, including vegetation, rock and debris removal, and recovery and stockpiling of cover soil;
- excavation, loading, hauling, placement, grading and compaction of tailings, waste rock and impacted soil in the following order: TP-1, WR-4/gossan area, WR-5, TP-4, BM, TP-5, TP-3, WR-2, WR-1, WR-3 and TP-2;
- installation of the cap liners and geocomposite drainage layer;
- placement and grading of stockpiled cover soil on the repository;
- constructing surface water diversion ditches strategically located to control water runon in the vicinity of the repository;
- backfilling and grading of excavated source areas with remaining stockpiled borrow soil;
- establishing vegetation on the repository, excavated waste and impacted soil areas, borrow soil stockpile area and haul roads by seeding, fertilizing and mulching;
- constructing a 4-strand, barbed-wire fence around the perimeter of the excavated source areas; and
- construction of a woven-wire fence around the repository.

## 9.0 COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES

This section provides a comparison of the reclamation alternatives retained for the Buckeye Mine site. The comparison focuses mainly on the following criteria: 1) the relative protectiveness of human health and the environment provided by the alternatives; 2) the long-term effectiveness provided by the alternatives; and 3) the estimated attainment of ARARs for each alternative. Qualitative comparisons are used to contrast the two threshold criteria of "overall protection of human health and the environment" and "compliance with ARARs" for each alternative. The primary balancing criteria are also compared, although, the evaluation of each of these criteria is very similar due to the technical similarities in the alternatives themselves, with the exception of costs. Table 9-1 presents a summary of the alternatives with respect to the first eight evaluation criteria.

Alternative 1 - No Action is not considered any further for this alternative would not address any of the environmental concerns raised for the site and would not meet contaminant-specific ARARs.

Of the alternatives retained for the site, Alternatives 4a, 4b and 4c provide a similar degree of overall protection of human health and the environment. Alternative 4a is expected to provide a slightly greater risk reduction compared to Alternatives 4b and 4c because the more extensive base liner system is more protective of groundwater resources; however, at a significantly higher cost. None of these alternatives are expected to achieve recreational or residential carcinogenic cleanup goals for arsenic.

Alternatives 4a, 4b, 4c are expected to achieve compliance with action-specific and location-specific ARARs. Chemical-specific ARARs for cadmium in groundwater are not expected to be met because the MCL is exceeded in groundwater immediately west of the site. However, removal of the waste sources may result in long-term improvements in groundwater quality. Achievement of chemical-specific ARARs for mercury in groundwater is unknown because the detection limit is greater than the MCL. Chemical-specific surface water quality ARARs are expected to be achieved, with the exception of cadmium and copper, which cannot be evaluated because the detection limit is greater than the chronic aquatic life standards.

When comparing the exposure pathways of direct contact, surface water and air, each of these alternatives provide similar long-term reduction for the contaminants at the site. Alternative 4a, would provide slightly greater long-term protection of human health and the environment compared to Alternatives 4b and 4c because the more extensive base liner system is more protective of groundwater resources; however, at a significantly higher cost.

None of the alternatives reduce the toxicity or volume of the contaminants of concern. The objective of the alternatives is to sever the exposure pathway and to limit the mobility of the contaminants. Limiting contaminant mobility will achieve protection of human health and the environment and will meet applicable ARARs identified for the site.

The short-term effectiveness is expected to be, for the most part, similar to each of the action alternatives. The alternatives are all technically similar and the construction steps required to implement them are expected to be accomplished in one field construction season of generally less than 90 days. Risk exposure to the community is expected to be minimal, with the exception of increased traffic on the roads in the vicinity of the site.

## Table 9-1. Comparative Analysis of Alternatives

| Assessment Criteria | Alternative 1: No Action | Alternative 4a: On-Site Disposal in a Constructed RCRA Repository | Alternative 4b: On-Site Disposal in a Constructed Modified RCRA Repository | Alternative 4c: On-Site Disposal in a Constructed Unlined Repository with a Multi-Layered Cap |
|---|---|---|---|---|
| **Overall Protection of Public Health, Safety and Welfare -** | No reduction in risk. | Consolidation, encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce human exposure. | Consolidation, encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce human exposure. | Consolidation, encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce human exposure. |
| Environmental Protectiveness | No protection offered. | Encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce overall ecological exposure. | Encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce overall ecological exposure. | Encapsulation and stabilization of tailings, waste rock and impacted soil sources is expected to significantly reduce overall ecological exposure. |
| **Compliance with ARARs -** | | | | |
| Contaminant Specific | Would not be met. | Drinking water MCL exceeds Cd in groundwater. Hg in groundwater unknown is because detection limit exceeds MCL. Cd and Cu status in Mill Creek is unknown because detection limit exceeds CALS. | Drinking water MCL exceeds Cd in groundwater. Hg in groundwater unknown is because detection limit exceeds MCL. Cd and Cu status in Mill Creek is unknown because detection limit exceeds CALS. | Drinking water MCL exceeds Cd in groundwater. Hg in groundwater unknown is because detection limit exceeds MCL. Cd and Cu status in Mill Creek is unknown because detection limit exceeds CALS. |
| Location Specific | None apply. | Location-specific ARARs would be met. | Location-specific ARARs would be met. | Location-specific ARARs would be met. |
| Action Specific | None apply. | Action-specific ARARs would be met. | Action-specific ARARs would be met. | Action-specific ARARs would be met. |
| **Long-Term Effectiveness and Performance -** | | | | |
| Magnitude of Risk Reduction | No reduction in CoCs in any environmental media, except by natural degradation/dilution. | High overall risk reduction is expected with tailings, waste rock and impacted soil removal and placement in an engineered repository. | High overall risk reduction is expected with tailings, waste rock and impacted soil removal and placement in an engineered repository. | Medium to high overall risk reduction is expected with tailings, waste rock and impacted soil removal and placement in an engineered repository. |
| Adequacy and Reliability of Controls | No controls over any on-site contamination, no reliability. | Primary sources of concern will be adequately isolated from human and environmental receptors. | Primary sources of concern will be adequately isolated from human and environmental receptors. | Primary sources of concern will be adequately isolated from human and environmental receptors. |
| **Reduction of Toxicity, Mobility and Volume -** | | | | |
| Treatment Process Used and Materials Treated | None | No treatment, however, removal and encapsulation of primary sources of concern is expected to provide significant reduction in mobility of CoCs for all pathways. | No treatment, however, removal and encapsulation of primary sources of concern is expected to provide significant reduction in mobility of CoCs for all pathways. | No treatment, however, removal and encapsulation of primary sources of concern is expected to provide significant reduction in mobility of CoCs for all pathways. |
| Volume of Contaminated Materials Treated | No reduction in CoC toxicity, mobility or volume. | No volume actively treated, however, 24,069 cubic yards of tailings, waste rock and impacted soil would be removed and isolated in the repository. | No volume actively treated, however, 24,069 cubic yards of tailings, waste rock and impacted soil would be removed and isolated in the repository. | No volume actively treated, however, 24,069 cubic yards of tailings, waste rock and impacted soil would be removed and isolated in the repository. |
| Expected Degree of Reduction | Minimal, via natural degradation only (potential for future increases in mobility of contaminants) | Volume or toxicity of wastes would not be reduced, however, mobility of CoCs would be significantly reduced. | Volume or toxicity of wastes would not be reduced, however, mobility of CoCs would be significantly reduced. | Volume or toxicity of wastes would not be reduced, however, mobility of CoCs would be significantly reduced. |
| **Short-Term Effectiveness -** | | | | |
| Protection of Community During Remedial Action | Not applicable. | Fugitive emissions control may be required during construction. Minimal impact on community with the exception of increased vehicle traffic in vicinity of site. | Fugitive emissions control may be required during construction. Minimal impact on community with the exception of increased vehicle traffic in vicinity of site. | Fugitive emissions control may be required during construction. Minimal impact on community with the exception of increased vehicle traffic in vicinity of site. |
| Protection of On-Site Workers During Removal Action | Not applicable. | Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes. | Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes. | Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes. |
| Environmental Impacts | Same as baseline conditions. | Environmental impacts possible due to tailings and waste rock excavation activities near stream. | Environmental impacts possible due to tailings and waste rock excavation activities near stream. | Environmental impacts possible due to tailings and waste rock excavation activities near stream. |
| Time Until Removal Action Objectives are Achieved | Not applicable. | One construction season. | One construction season. | One construction season. |
| **Implementability -** | | | | |
| Ability to Construct and Operate | No construction or operation involved. | Easily implementable. Liner installation will require diligent construction QA/QC. | Easily implementable. Liner installation will require diligent construction QA/QC. | Easily implementable. Liner installation will require diligent construction QA/QC. |
| Ease of Implementing More Action If Necessary | Not applicable. | Easily implementable if additional armoring or stabilization, etc. determined necessary. | Easily implementable if additional armoring or stabilization, etc. determined necessary. | Easily implementable if additional armoring or stabilization, etc. determined necessary. |
| Availability of Services and Capacities | Not applicable. | Available locally and within state. | Available locally and within state. | Available locally and within state. |
| Availability of Equipment and Materials | Not applicable. | Available locally and within state. | Available locally and within state. | Available locally and within state. |
| **Estimated Total Present Worth Cost** | **$0** | **$1,062,136** | **$704,943** | **$627,582** |

On-site workers will be required to have hazardous materials handling training and will be subject to a site-specific Health and Safety Plan for their protection. Tailings and waste rock excavation activities near the Mill Creek stream channel and floodplain may have some short term impact to the environment, although efforts will be made to minimize the risk by using best management practices. Because each of the alternatives will involve excavation and haulage of significant volumes of tailings and/or waste rock and/or impacted soil, localized air quality impacts may occur from fugitive dust emissions. Water sprays will be used to control dust emissions and to minimize dust exposure.

For implementability, Alternative 4c would be the easiest alternative to implement because the repository lining requirements are less than under Alternatives 4a and 4b. Alternative 4a would be the most technically difficult to implement because of the increased construction quality control for the repository liner construction, liner seams and construction of the leachate collection system. Implementation of Alternative 4b would be similar to Alternative 4a, except that the liner requirements would be reduced because no leachate collection system or flexible membrane liners would be installed.

Because of the health and safety requirements associated with the waste sources, only properly trained and experienced contractors/crews should perform the specified work. Inexperienced contractors and crews would likely prolong the construction phase and may result in increased costs and compromised safety and performance.

Table 9-1 indicates the estimated total costs associated with each alternative. The no action alternative is not considered feasible because it would not address the identified risks to human health and the environment at the site. Of the various action alternatives considered for the site, Alternative 4c is the least costly, and Alternative 4a is the most costly. Estimated costs for Alternatives 4a, 4b and 4c are $1,062,136, $704,943 and $627,582, respectively.

## 10.0 PREFERRED ALTERNATIVE

The principal waste sources associated with the Buckeye Mine site that are contributing to environmental impacts are the mill tailings, waste rock and impacted soil. The mill tailings are elevated in metals/metalloids including: antimony, arsenic, cadmium, copper, lead, mercury, silver and zinc (concentrations greater than three times background soils). The waste rock is elevated in antimony, arsenic, cadmium, copper, iron, lead, manganese, silver and zinc. The impacted soil at the former Brandon Mill is elevated in antimony, arsenic, cadmium, copper, iron, lead, silver and zinc.

The greatest risk to human health and the environment from waste sources associated with the Buckeye Mine site are the tailings, waste rock and impacted soil via the direct contact, surface water, groundwater and air exposure pathways. Based on the risk assessment, the principal contaminants of concern and exposure pathways for human health are: antimony, arsenic, iron and lead (residential cleanup goals) and lead (recreational cleanup goals) via ingestion/inhalation of tailings, waste rock and impacted soil; ingestion/inhalation of arsenic (carcinogenic risk based on residential and recreational cleanup goals); ingestion of arsenic in water (carcinogenic risk based on residential and recreational cleanup goals; and ingestion of arsenic via fish consumption (carcinogenic risk based on recreational cleanup goals).

The principal contaminants of concern and ecological exposure pathways are: cadmium and silver via exposure of aquatic life to surface water; lead via deer ingestion of tailings and waste rock salts; and plant phytotoxicity to arsenic, cadmium, copper, lead and zinc.

Tailings piles TP-3 and TP-4, waste rock piles WR-4 and WR-5 and impacted soil from the former Brandon Mill exceeded TCLP regulatory levels for lead. Acid-base accounting results and field evidence indicate that tailings piles TP-4 and TP-5, waste rock piles WR-4 and WR-5 and impacted soil from the former Brandon Mill are potentially acid generating. The TCLP and acid-base accounting results suggest that a repository base liner may be appropriate.

The tailings and waste rock piles are located in or near the Mill Creek stream drainage or in an ephemeral tributary to Mill Creek. The tailings pile TP-4 and waste rock pile WR-5 are currently subject to erosion and infiltration of surface water, which may contribute metals loading directly to Mill Creek surface water and stream sediment during high flows. Removal of the tailings and waste rock from the drainage to an engineered repository would provide protection from the existing erosion and infiltration problems with a high degree of overall risk reduction.

Based on the conclusions of the detailed analysis and comparative analysis of alternatives, Alternative 4b - On-Site Disposal in a Constructed Modified RCRA Repository is proposed as the preferred alternative for reclamation of the tailings, waste rock and impacted soil associated with Buckeye Mine site. This alternative is considered the most appropriate and cost-effective means to reduce risk to human health and the environment to an acceptable level. In summary, the reclamation strategy for Alternative 4b involves removing the tailings, waste rock and impacted soil associated with the Buckeye Mine site and disposing these wastes in a modified RCRA repository which includes a single geosynthetic clay liner (without a leachate collection and removal system) and a multi-layered cap. The sources to be disposed in the repository include the tailings piles TP-1 through TP-5, waste rock piles WR-1 through WR-5 and impacted soils from the former Brandon Mill area.

The proposed repository would be located in an open and relatively flat area near a ridgeline north of the former Buckeye Mill area. This area comprises approximately 1.52 acres that appear to be appropriate for the construction of a repository.

After the repository construction, waste excavation, and waste placement are complete, selected excavated areas backfilled with cover soil and the disturbed areas would be revegetated. A runon/runoff control ditch would be constructed in the area of the repository to divert runoff away from the repository cap. Barbed-wire fencing would be placed around the excavated waste source areas to allow the establishment of vegetation without interference from livestock. A woven-wire fence would be constructed around the repository to limit access.

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# APPENDIX A

# XRF ANALYTICAL RESULTS FOR THE BUCKEYE MINE SITE

**Buckeye Mine Tailings Pile TP1 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP1-1-0-2.8 | <23.85 | 84.4 | 178.7 | <78 | 1600 | <136.2 | <85.5 | 1489.6 | <330 | <930 | <1244.4 | 35686.4 | <1800 | 1729.6 | Tailings org brn silty sand |
| TP1-1-0-2.8 | 32.3 | 101.4 | 167.9 | <60 | 1760 | <105.75 | 75.4 | 2059.2 | <375 | 7174.4 | <960 | 37888 | <1470 | 3328 | Tailings org brn silty sand |
| TP1-1-0-2.8 | <13.65 | 86 | 204.7 | <43.05 | 1069.6 | <65.4 | <44.85 | 1520 | <180 | 597.2 | <660 | 29593.6 | 1409.6 | 1220 | Tailings org brn silty sand |
| TP1-1-2.8-5.4 | <13.8 | 37.9 | <14.55 | <44.25 | 514.8 | 63.6 | <41.55 | 326.2 | <240 | 3188.8 | <735 | 28595.2 | 1320 | 2108.8 | Tailings lt grn silty clay |
| TP1-1-5.4-9.6 | <17.55 | 57.2 | 460.4 | <51.6 | 152.6 | <45.3 | <39.45 | 320 | <225 | <690 | <945 | 37990.4 | <1304.4 | 1360 | Talings lt brn-brn silty sand |
| TP1-2-0-1.7 | <16.05 | 112.7 | 79 | <50.1 | 1020 | <74.85 | <51.3 | 1380 | 221.8 | <615 | <825 | 31590.4 | <1125 | 1659.2 | Tailings yw brn silty sand |
| TP1-2-1.7-3.7 | <14.7 | 30.8 | 35.5 | <42.75 | 571.6 | 155.6 | <41.25 | 305 | 382.2 | <660 | <900 | 42880 | 2040 | 1309.6 | Tailings lt gry - red brn clayey silt |
| TP1-2-3.7-8.0 | <16.5 | 101.4 | 17 | <47.4 | 388.2 | 81.3 | <47.1 | 1029.6 | <210 | <645 | <870 | 34380.8 | 1460 | 1189.6 | Tailings lt brn silty sand |
| TP1-3-0-1.6 | <15.9 | 64.4 | 165.8 | <63.9 | 2880 | <119.7 | <61.35 | 761.2 | 383 | <675 | <915 | 39091.2 | <1185 | 1509.6 | Tailings org brn silty sand |
| TP1-3-1.6-2.6 | <14.7 | 50.2 | 18.4 | <42.6 | 116.7 | 71.5 | <36 | 555.2 | <195 | <630 | <855 | 37580.8 | <1140 | 1060 | Tailings clayey silt |
| TP1-3-2.6-4.2 | <14.25 | 40.2 | 18.6 | <43.95 | 187.2 | 49.4 | <57.45 | 3628.8 | <195 | <510 | <690 | 22899.2 | <975 | 1449.6 | Tailings fn gr sand w/thin bands red brn |
| TP1-3-4.2-5.8 | <15 | 22.2 | <16.35 | <53.1 | 1469.6 | 157.1 | <58.65 | 1889.6 | <210 | <645 | <870 | 35200 | <1140 | 1360 | Tailings bluish gry silty clay |
| TP1-3-5.8-12.9 | <16.05 | 160.1 | 132.2 | <42.15 | 223.6 | <41.25 | <37.65 | 434.4 | <150 | 505.6 | <570 | 17689.6 | 1340 | 991.2 | Tailings lt brn - brn fn gr sand |
| TP1-4-0-2.9 | <17.4 | 54 | 165.6 | <63.15 | 2379.2 | 141.8 | <75.6 | 2819.2 | 291.6 | 798.4 | <990 | 41881.6 | 2560 | 1200 | WR + Tailings yw-org brn sand + gravel |
| TP1-4-2.9-3.5 | 17.5 | 43.8 | <15.9 | <49.8 | 575.6 | 320.8 | <53.1 | 1100 | <225 | 774.4 | <945 | 42777.6 | 2449.6 | 1260 | Tailings redish brn silt |
| TP1-4-3.5-8.3 | <15.3 | 119.1 | 253.2 | <44.25 | 212.2 | <41.85 | <35.4 | 628 | <165 | 677.6 | <645 | 22899.2 | <945 | 1260 | Tailings lt brn - brn silty sand |
| TP1-7-0-3.0 | <15.9 | 47.1 | 68.3 | <46.95 | 419.2 | <55.5 | <44.1 | 829.6 | <225 | 1009.6 | <1005 | 51686.4 | 2089.6 | 1029.6 | WR; v. fn sand + v. abund rock |
| 29-451-TP1-1 | 22.2 | 73.8 | 171.7 | <70.2 | 1929.6 | <122.4 | <74.85 | 1769.6 | <270 | <765 | <1035 | 34380.8 | <1440 | 1129.6 | Composite of TP1-1-0-2.8; TP1-3-0-1.6; TP1-2-0-1.7 |
| 29-451-TP1-2 | <15 | 28.6 | <16.5 | 66.4 | 761.2 | <73.05 | <45.6 | 343.8 | <180 | <555 | <750 | 23897.6 | 1189.6 | <375 | Composite of TP1-1-2.8-5.4; TP1-3-4.2-5.8 |
| 29-451-TP1-3 | <20.4 | 102.5 | 220.4 | <59.7 | 291.8 | <62.1 | <51 | 691.6 | <225 | 705.2 | <915 | 26188.8 | 1460 | 1109.6 | Composite of TP1-2-3.7-8.0; TP1-1-5.4-9.6; TP1-3-5.8-12.9; TP1-4-3.5-8.3 |
| Mininum detected | <23.85 | 22.2 | <16.5 | <78 | 116.7 | <136.2 | 75.4 | 305 | 221.8 | 505.6 | 0 | 17689.6 | 1189.6 | 991.2 | |
| Maximum | 32.3 | 160.1 | 460.4 | 66.4 | 2880 | 320.8 | 75.4 | 3628.8 | 383 | 7174.4 | 0 | 51686.4 | 2560 | 3328 | |
| Mean | 26.075 | 72.73 | 165.75 | 66.4 | 978.15 | 151.3222 | 75.4 | 1264.29 | 313.9 | 2101.02 | 0 | 33738.88 | 1731.84 | 1434.947 | |
| No. Samples | 3 | 20 | 16 | 1 | 20 | 8 | 1 | 20 | 4 | 9 | 0 | 20 | 10 | 19 | |
| | | | | | | | | | | | | | | | |
| TP1-5-0.2-1.5 | <14.25 | 152 | 152.9 | <39.45 | 45.5 | <28.95 | <26.4 | 100.8 | <124.2 | <375 | <495 | 14400 | 869.6 | 628 | Native tan silt + abund rock |
| TP1-2-8.0-9.8 | <15.75 | 55 | 686.4 | <47.25 | 191.4 | <41.1 | <34.35 | 254.6 | <210 | <645 | <885 | 41395.2 | <1140 | 1569.6 | Native - drk gyish to blk, mica-rich |
| TP1-6-0.3-0.9 | <16.2 | 115.3 | 109.3 | <47.55 | 712.4 | <65.25 | <46.95 | 792 | <225 | <705 | <975 | 47590.4 | 3129.6 | 1329.6 | Native tan silt + abund rock |
| TP1-1-9.6-12.4 | <17.4 | 31.5 | 670 | <52.95 | <53.25 | <36.6 | <36.15 | <110.1 | <255 | <855 | <1170 | 57856 | 2219.2 | 1560 | Native - drk brn, mica-rich |
| TP1-ORE | <17.2 | 147.4 | 137.8 | <75.15 | 134 | <55.2 | <51.9 | <145.95 | <330 | 2289.6 | <1454.4 | 64358.4 | 2219.2 | 1640 | rock sample |

**Buckeye Mine Tailings Pile TP2 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP2-1-0-2.2 | <14.1 | 114.4 | 70 | <42 | 167.5 | 40.4 | <29.7 | 179.7 | <150 | <480 | <645 | 24793.6 | <930 | 1708.8 | Tailings tan silty sand; 120 sec |
| TP2-1-0-2.2 | <11.85 | 96.6 | 58.9 | <35.4 | 159.1 | 63.6 | <25.35 | 189.5 | <134.85 | <420 | <570 | 25689.6 | 840 | 1420 | Tailings tan silty sand; 200 sec |
| TP2-1-2.2-3.9 | <15.9 | <12.75 | 26.4 | <46.8 | 803.2 | 587.6 | <53.1 | 217.2 | <315 | <1050 | <1440 | 86579.2 | 2209.6 | 1060 | Tailings org brn clayey silt |
| TP2-1-3.9-8.8 | <15.15 | 87.6 | 298.4 | <43.2 | 220.2 | <44.55 | <41.4 | 625.6 | <195 | <555 | <735 | 26598.4 | <1020 | 1120 | Tailings tan to lt brn silty sand |
| TP2-2-0-5.0 | <11.5 | 160.4 | 201.1 | <44.7 | <45.75 | <33.15 | <34.2 | 111.5 | <180 | 865.6 | <630 | 18291.2 | <960 | 1649.6 | Tailngs tan silty sand |
| TP2-2-5.0-6.0 | <15.9 | 100.8 | 251.6 | <43.2 | 84.2 | <33.6 | <29.85 | 218 | <147.75 | <420 | <555 | 14796.8 | <780 | 518 | Tailngs tan silty sand |
| TP2-3-0-0.6 | <17.55 | 107.9 | 220.2 | <55.65 | 1040 | <84.15 | <73.2 | 3488 | 1929.6 | 650.4 | <855 | 31283.2 | 1828.8 | 989.6 | WR cap on tailings |
| TP2-3-0.6-4.6 | <14.85 | 173.5 | 133.6 | <37.35 | 57.8 | <27.3 | <25.65 | 136.4 | <127.95 | <390 | <510 | 15897.6 | <735 | 818.8 | Tailings lt brn silty sand |
| TP2-4-0-2.1 | <18.6 | 147.5 | 132.9 | <54.3 | 1500 | <94.5 | <69.45 | 3638.4 | 865.6 | <675 | <900 | 34585.6 | 1440 | 2148.8 | Tailings + WR yw to org brn |
| TP2-4-2.1-7.7 | 17.1 | 156.2 | 145.8 | <43.5 | 79.1 | <36.15 | <38.4 | 822.4 | <165 | 646 | <600 | 18496 | <945 | 1609.6 | Tailings lt brn silty sand |
| TP2-4-7.7-8.7 | <16.05 | 131.9 | 250 | <43.5 | 84.9 | <36 | <37.05 | 452.4 | <165 | <495 | <660 | 21094.4 | 1140 | 1009.6 | Tailings lt brn silty sand |
| TP2-5-0-4.8 | <15 | 125.1 | 232 | <42.45 | 760.8 | <61.95 | <39.6 | 552.4 | <165 | <480 | <645 | 23398.4 | <975 | 1720 | Tailngs brn silty sand |
| TP2-5-4.8-6.8 | <17.7 | 74.5 | 474.4 | <55.5 | 796.4 | <75.15 | <55.35 | 1360 | <285 | 2249.6 | <1005 | 42393.6 | 1988.8 | 1580 | Tailings? Lt tan -brn fn-med sand + gravel |
| TP2-6-0-0.5 | <18.3 | 29.9 | 334.6 | <81 | 5718.4 | <120 | <61.7 | 373.8 | <315 | 2960 | <1185 | 57856 | <1650 | 1960 | WR strongly oxid |
| TP2-6-0.5-2.1 | 19.1 | 135.6 | 181.3 | <39.75 | 93.1 | <30.45 | <32.85 | 991.2 | <150 | 589.6 | <585 | 20800 | <915 | 1859.2 | Tailings? choc brn silty sand + gravel |
| TP2-6-2.1-4.9 | 20.4 | 71.3 | 231.4 | <40.8 | 92.4 | <34.5 | <38.55 | 1200 | <165 | 465.2 | <570 | 17600 | 1189.6 | 2160 | Tailings brn silty sand |
| 29-451-TP2-1 | 21.1 | 105.5 | 224 | <48.3 | 162 | <44.1 | <38.1 | 346.8 | <180 | <495 | <660 | 17292.8 | <1005 | 1049.6 | Composite of TP2-4-0-2.1; TP2-1-2.2-3.9 |
| 29-451-TP2-2 | <19.5 | 142.3 | 174.8 | <52.65 | 140.9 | <45.45 | <38.25 | 340 | <180 | <525 | <690 | 16192 | <1050 | 908 | Composite of TP2-2-0-5; TP1-3-0.6-4.6; TP2-5-0-4.8; TP2-6-2.1-4.9 |
| Mininum detected | 17.1 | 29.9 | 26.4 | 0 | 57.8 | 40.4 | 0 | 111.5 | 865.6 | 465.2 | 0 | 14796.8 | 840 | 518 | |
| Maximum | 21.1 | 173.5 | 474.4 | 0 | 5718.4 | 587.6 | 0 | 3638.4 | 1929.6 | 2960 | 0 | 86579.2 | 2209.6 | 2160 | |
| Mean | 19.425 | 115.35 | 202.3 | 0 | 703.53 | 230.5333 | 0 | 846.85 | 1397.6 | 1203.77 | 0 | 28535.47 | 1519.543 | 1404.978 | |
| No. Samples | 4 | 17 | 18 | 0 | 17 | 3 | 0 | 18 | 2 | 7 | 0 | 18 | 7 | 18 | |
| | | | | | | | | | | | | | | | |
| TP2-3-4.6-5.7 | <17.55 | 50.5 | 586 | <53.25 | 220.2 | <51.9 | <64.35 | 3488 | <270 | <750 | <1005 | 42496 | 1600 | 1329.6 | Native? Drk gry sand + minor gravel |
| TP2-6-4.9-6.1 | <15.75 | 47.4 | 106.2 | <44.85 | 121 | <46.2 | <85.2 | 10099.2 | <285 | 913.6 | <840 | 33792 | 1269.6 | 1220 | Native; mod oxid org FeOx |

**Buckeye Mine Tailings Pile TP3 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP3-1-0-5.5 | <15.75 | 136.4 | 213 | <41.25 | <42.15 | <31.05 | <28.8 | 95.8 | <136.5 | <405 | <540 | 15692.8 | <825 | 801.6 | Tailings tan silty sand |
| TP3-2-0-1.8 | 60.6 | 24.7 | 36.6 | <69.3 | 4988.8 | 270.8 | 99.1 | 379.4 | 552 | 4128 | <930 | 53555.2 | 2219.2 | 2729.6 | Tailings finely banded brn clayey silt |
| TP3-2-1.8-4.9 | <14.7 | 23.1 | 16.2 | <50.25 | 234.4 | <47.85 | <39.6 | 418.8 | <225 | 2849.6 | <765 | 28979.2 | <1140 | 1779.2 | Tailings bluish gry w/ org layers silty clay |
| TP3-2-1.8-4.9 | 15.6 | 19.8 | 15.3 | <22.8 | 241.2 | <31.5 | <25.35 | 433.2 | <121.2 | 699.2 | <510 | 27392 | 1209.6 | 1589.6 | Tailings bluish gry w/ org layers silty clay |
| TP3-2-4.9-8.8 | <11.7 | 180.6 | 141.3 | <29.55 | 52 | <23.4 | <22.5 | 78.4 | <108.3 | 666.8 | <435 | 18598.4 | 804 | 1480 | Tailings tan silty sand |
| TP3-3-0-4.8 | <14.55 | 152.5 | 153.4 | <36.45 | 324.2 | <39.45 | <31.95 | 643.2 | <300 | <360 | <495 | 16793.6 | <735 | 1109.6 | Tailings tan-lt brn silty sand |
| TP3-4-0-5.9 | <13.65 | 179.3 | 169.4 | <39.9 | <39 | <27.6 | <25.5 | 71.5 | <130.8 | 423.2 | <525 | 16396.8 | <810 | 1380 | Tailings lt brn silty sand |
| TP3-5-0-2.3 | 36.9 | 60.9 | 64.7 | <68.4 | 4608 | <142.95 | <74.1 | 1748.8 | 133.2 | 1460 | <825 | 33382.4 | 1680 | 2409.6 | Tailings lt tan silty sand w/3" wht sand layer |
| TP3-5-2.3-5.4 | <15.45 | 141.5 | <14.55 | 84.9 | 169.9 | <41.4 | <36.6 | 518.8 | <180 | 700.4 | <810 | 37196.8 | 2268.8 | <405 | Tailngs tan to yw tan silty sand w/thin red brn silt layers |
| TP3-5-5.4-10.2 | <15.9 | 124.9 | 43 | <45.9 | 170.7 | <42.45 | <38.1 | 469.2 | <180 | 589.6 | <765 | 30694.4 | 1640 | 1380 | Tailings tan silty sand more massive |
| 29-451-TP3-1 | <20.4 | 146 | 174.5 | <51.9 | 144.2 | <45 | <37.65 | 185.8 | <180 | <540 | <720 | 16396.8 | <1110 | 1200 | Composite of TP3-3-0-4.8; TP3-4-0-5.9; TP3-1-0-5.5 |
| 29-451-TP3-2 | <16.65 | 16.2 | 30.8 | <64.5 | 1049.6 | <91.95 | <53.25 | 365.2 | <210 | <615 | <840 | 24896 | 1240 | <435 | Composite of TP3-2-0-1.8; TP3-2-1.8-4.9 |
| 29-451-TP3-3 | <20.85 | 159.5 | 104.1 | <60.6 | 148.3 | <53.85 | <46.35 | 279.8 | <225 | <660 | <900 | 23296 | 1699.2 | 1189.6 | Composite of TP3-2-4.9-8.8; TP3-5-5.4-10.2 |
| Mininum detected | 15.6 | 16.2 | 15.3 | 84.9 | 52 | 270.8 | 99.1 | 71.5 | 133.2 | 423.2 | 0 | 15692.8 | 804 | 801.6 | |
| Maximum | 60.6 | 180.6 | 213 | 84.9 | 4988.8 | 270.8 | 99.1 | 1748.8 | 552 | 4128 | 0 | 53555.2 | 2268.8 | 2729.6 | |
| Mean | 37.86 | 104.1467 | 99.32857 | 84.9 | 1320.931 | 270.8 | 99.1 | 500.5467 | 342.6 | 1606.8 | 0 | 27501.23 | 1583.36 | 1583.077 | |
| No. Samples | 3 | 13 | 12 | 1 | 11 | 1 | 1 | 13 | 2 | 8 | 0 | 13 | 8 | 11 | |
| | | | | | | | | | | | | | | | |
| TP3-5-10.2-11.2 | <16.65 | 21 | 364.6 | <49.95 | 79.8 | <39.45 | <38.85 | 320.8 | <210 | 988 | <930 | 37376 | 1680 | 1699.2 | Native strong oxid yw-org FeOx w/ rock frag |
| TP3-4-5.9-6.8 | <17.4 | <18.6 | 570.4 | <53.1 | <56.1 | <39.9 | <42 | 494 | <240 | 1080 | <1065 | 46489.6 | 1960 | 1489.6 | Native weatherd igneous rock? |
| TP3-2-8.8-9.3 | <14.55 | 58.4 | 425.2 | <41.85 | <45.75 | <32.7 | <38.85 | 614.4 | <300 | 7520 | <765 | 34483.2 | 2148.8 | 2040 | Native lt grnish gry fn-med sand + gravel |

**Buckeye Mine Tailings Pile TP4 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP4-1-0-3.1 | <16.95 | 31 | 45.3 | <57.15 | 1699.2 | <111 | 125.3 | 5788.8 | <480 | 12697.6 | <855 | 25689.6 | <1290 | 2059.2 | Tailings tan to gry silty sand; some intense org-yw brn FeOx |
| TP4-3-0-2.5 | 26.9 | 43.6 | 23.7 | <58.65 | 1500 | 291.8 | <90.45 | 6227.2 | <375 | 6019.2 | <945 | 37478.4 | <1424.4 | 3388.8 | Tailings lt brn to gry sand |
| TP4-2-0-2.0 | <15.45 | <13.05 | 32.9 | <51 | 2068.8 | <103.05 | <56.85 | 1109.6 | <180 | <420 | <525 | 11596.8 | <855 | 1420 | Tailings variably colored org to yw to lt tan silty sand |
| TP4-2-2.0-2.6 | <11.25 | 17.7 | 141.9 | <49.95 | 5520 | <119.1 | <95.1 | 17894.4 | 1560 | <540 | <705 | 44083.2 | 992 | 1469.6 | Tailings bluish gry sandy silt |
| TP4-4-0-3.7 | <16.35 | 28.7 | 217 | <64.5 | 2920 | <123.9 | <71.55 | 1449.6 | <330 | 5520 | <810 | 27776 | <1155 | 1779.2 | Tailings org brn silty sand |
| TP4-4-3.7-5.0 | <17.4 | 42.9 | 182.6 | <74.4 | 4227.2 | <150 | <119.85 | 10496 | 822.4 | 4659.2 | <930 | 34995.2 | <1394.4 | 2409.6 | Tailings bluish gry clayey silt |
| TP4-5-0-2.7 | <10.05 | 19.9 | 109.4 | <34.8 | 1920 | <69.75 | <55.65 | 5948.8 | 530 | 482.4 | <450 | 18099.2 | 736 | 1240 | Tailings tan silty sand |
| TP4-5-2.7-6.3 | <17.4 | <16.35 | 124.3 | <67.95 | 3628.8 | <148.65 | <144.9 | 20697.6 | 1000 | 9664 | <1020 | 41088 | <1500 | 3619.2 | Tailings bluish gry clayey silt |
| TP4-6-0-3.2 | 20.4 | 42.3 | <19.05 | <58.5 | 1040 | 131.7 | <97.95 | 6320 | <495 | 11795.2 | <1020 | 37299.2 | <1484.4 | 3628.8 | Tailings brn sand w/gry sand layer |
| TP4-7-0-1.9 | <15.6 | 38.8 | 99.6 | <61.5 | 2680 | <118.05 | <58.95 | 444.8 | 246.8 | <525 | <705 | 20697.6 | <885 | 546.4 | Tailings strong yw brn oxid silty sand |
| TP4-SALT | <15.6 | 14.1 | 83.1 | <48.9 | 1200 | <93.15 | <113.1 | 13299.2 | 445.6 | 4038.4 | <705 | 18892.8 | <1140 | 2228.8 | Tailings salts rep composite of white salts on top of tailings |
| TP4-8-0-2.2 | <15 | 25 | 76.1 | <47.4 | 1529.6 | <89.25 | <52.65 | 172.8 | <330 | 6828.8 | <690 | 19699.2 | <1020 | 1600 | Tailings intense oxid org silty sand w/minor lt tan clayey silt layer |
| TP4-10-0-0.4 | <12 | 27.2 | 67.5 | <50.1 | 3868.8 | <110.7 | <51.3 | 355.4 | 262.4 | <435 | 755.6 | 21299.2 | <750 | 858.4 | Tailings tan to lt tan sand |
| TP4-11-0-2.5 | <15 | 31.9 | 173.8 | <62.4 | 3318.4 | <120.15 | <60.15 | 754 | <240 | 1180 | <855 | 36992 | <1140 | 1969.6 | Tailings strongly oxid org silty sand w/minor white clay-rich layers |
| TP4-11-2.5-3.1 | <19.8 | <23.7 | 169.3 | <115.95 | 12896 | <285 | <147 | 7097.6 | 1828.8 | <945 | 1509.6 | 49792 | <1650 | 2468.8 | Tailings bluish gry clayey silt to silty clay |
| 29-451-TP4-1 | <18 | 25.2 | 94.9 | <63.75 | 2009.6 | <125.25 | <81.75 | 2809.6 | 327 | <570 | <750 | 18099.2 | <1125 | 1060 | Composite of TP4-1-0-3.1; TP4-2-0-2.0; TP4-7-0-1.9 |
| 29-451-TP4-2 | <19.65 | 25.8 | 177.7 | <92.1 | 6400 | <225 | <142.95 | 10598.4 | 3308.8 | <855 | <1110 | 35891.2 | <1500 | 1240 | Composite of TP4-2-2.0-2.6; TP4-4-3.7-5.0; TP4-11-2.5-3.1 |
| 29-451-TP4-2 | <20.85 | <22.65 | 149.7 | <100.95 | 6448 | <240 | <150 | 10195.2 | 3240 | <930 | <1185 | 35276.8 | <1650 | 896.8 | rerun for precision check |
| 29-451-TP4-3 | <19.2 | 30.5 | 41.2 | <65.55 | 1420 | 238.6 | <100.35 | 6419.2 | 372.6 | <720 | <960 | 28876.8 | 1960 | 1389.6 | Composite of TP4-3-0-2.5; TP4-5-0-2.5; TP4-6-0-3.2 |
| Mininum detected | 20.4 | 14.1 | 23.7 | 0 | 1040 | 131.7 | 125.3 | 172.8 | 246.8 | 482.4 | 755.6 | 11596.8 | 736 | 546.4 | |
| Maximum | 26.9 | 43.6 | 217 | 0 | 12896 | 291.8 | 125.3 | 20697.6 | 3308.8 | 12697.6 | 1509.6 | 49792 | 1960 | 3628.8 | |
| Mean | 23.65 | 29.64 | 111.67 | 0 | 3489.18 | 220.7 | 125.3 | 6740.96 | 1162.03 | 6288.48 | 1132.6 | 29664.34 | 1229.33 | 1856.46 | |
| No. Samples | 2 | 15 | 18 | 0 | 19 | 3 | 1 | 19 | 12 | 10 | 2 | 19 | 3 | 19 | |
| | | | | | | | | | | | | | | | |
| TP4-PILES | <16.05 | 112.5 | 187.1 | <42.3 | <44.25 | <31.65 | 50.8 | <131.25 | <270 | 4588.8 | 718.8 | 14988.8 | <900 | 2009.6 | Native? Two cone piles on SW side of TP4 outside of fence-line |
| TP4-10-0.4-1.0 | <16.8 | 149.6 | 104.7 | <45.6 | <49.5 | 59.6 | <36.3 | 142.6 | <225 | <705 | <960 | 42496 | <1290 | 1680 | Native drk brn silty sand + minor gravel |
| TP4-7-1.9-2.6 | <16.8 | 103.1 | 177.5 | <45.15 | 63.2 | <39.3 | <44.7 | 798.8 | <330 | 5238.4 | <885 | 32793.6 | <1244.4 | 2059.2 | Native brn sand w/mod abund rock |
| TP4-3-2.5-3.8 | 20.3 | 63.3 | 110.9 | <42.45 | 122.7 | <54.45 | 188.4 | 3200 | <480 | 16396.8 | <840 | 30182.4 | <1244.4 | 2840 | Native drk brn sand to silt w/mod gravel |
| TP4-1-3.1-3.7 | <18 | 153.7 | 39.3 | <46.95 | <79.95 | <67.65 | 1189.6 | 2468.8 | <780 | 50892.8 | <915 | 29081.6 | <1274.4 | 2160 | Native drk brn sandy soil w/gravel |
| TP4-8-2.2-3.0 | <20.25 | 89.7 | 72.8 | <55.95 | <98.1 | <82.35 | 902.4 | 3987.2 | <840 | 43084.8 | <1170 | 40780.8 | <1650 | 3968 | Native brn sand w/mod abund rock |

**Buckeye Mine Tailings Pile TP5 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP5-1-0-1.1 | <15.75 | 61.6 | 206.2 | <58.35 | 2449.6 | <108 | <54.9 | 564.8 | <195 | <555 | <750 | 25190.4 | <1020 | 1149.6 | Tailings lt brn silty sand |
| TP5-1-1.1-1.6 | 27.6 | 110.5 | 89.5 | <47.25 | 213.2 | <50.55 | <43.95 | 283.2 | <330 | 4368 | <1005 | 39577.6 | <1380 | 2739.2 | Native choc brn silty sand + gravel |
| TP5-2-0-0.5 | 457.2 | 90.3 | 80.8 | <79.05 | 1369.6 | <144.45 | 696 | 1429.6 | <1125 | 40576 | 3488 | 283852.8 | 13593.6 | 101990.4 | Tailings lt brn silty sand |
| TP5-3-0-0.6 | <17.85 | 145.8 | 123.9 | <54.45 | 1140 | 112.6 | <58.5 | 2219.2 | 274.6 | <690 | <930 | 37299.2 | <1230 | 1429.6 | Tailings lt brn silty sand |
| TP5-4-0-0.3 | <16.35 | 101.4 | 124.3 | <49.65 | 1229.6 | <81.9 | <48.15 | 605.6 | <195 | <585 | <780 | 29184 | <1050 | 995.2 | Tailings lt tan silty sand |
| TP5-5-0-2.5 | <16.95 | 48.9 | 92.9 | <59.55 | 2369.6 | <115.8 | <64.65 | 1229.6 | 341.4 | <585 | <795 | 25292.8 | <1110 | 1880 | Tailings lt tan-lt org brn silty sand w/thin layers beige clayey silt |
| 29-451-TP5-1 | <21 | 123 | 123.8 | <62.1 | 1409.6 | <109.65 | <70.35 | 1349.6 | <270 | <795 | <1080 | 35200 | <1500 | 1979.2 | Composite of TP5-1-0-1.1; TP5-3-0-0.6; TP5-4-0-0.3 |
| 29-451-TP5-2 | <19.8 | 72.2 | 106.3 | <77.55 | 2520 | 238.4 | <94.05 | 3000 | 430 | <810 | <1110 | 33280 | <1500 | 941.6 | Composite of TP5-5-0-2.5; BM15-0-1.2 |
| Mininum detected | 27.6 | 48.9 | 80.8 | 0 | 213.2 | 112.6 | 696 | 283.2 | 274.6 | 4368 | 3488 | 25190.4 | 13593.6 | 941.6 | |
| Maximum | 457.2 | 145.8 | 206.2 | 0 | 2520 | 238.4 | 696 | 3000 | 430 | 40576 | 3488 | 283852.8 | 13593.6 | 101990.4 | |
| Mean | 242.4 | 94.2125 | 118.4625 | 0 | 1587.65 | 175.5 | 696 | 1335.2 | 348.6667 | 22472 | 3488 | 63609.6 | 13593.6 | 14138.1 | |
| No. Samples | 2 | 8 | 8 | 0 | 8 | 2 | 1 | 8 | 3 | 2 | 1 | 8 | 1 | 8 | |
| | | | | | | | | | | | | | | | |
| TP5-2-0.5-1.1 | <20.1 | 131.8 | 127.3 | <51.6 | <64.2 | <48.6 | 221.8 | 473.2 | <540 | 17689.6 | <1125 | 43980.8 | <1500 | 3108.8 | Native choc brn silty sand + gravel |
| TP5-4-0.3-0.8 | <16.5 | 162.2 | 112.8 | <45.15 | 167.2 | <44.55 | <44.7 | 1380 | <195 | <LOD | <810 | 30080 | <1080 | 776 | Native choc brn silty sand + gravel |

**Brandon Mill Waste XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BM1-0-0.5 | <19.05 | 128.7 | 112 | <82.35 | 5849.6 | 432 | <85.35 | 447.6 | <270 | <855 | <1155 | 52684.8 | <1484.4 | 1229.6 | Tailings lt tan to lt brn silty sand w/mod yw oxidation |
| BM1-0.5-1.0 | <16.65 | 118.5 | 75.9 | <57.3 | 1760 | 446.4 | <57.6 | 312.8 | <240 | <765 | <1035 | 48588.8 | <1364.4 | 1209.6 | Appears to be Native - choc brn silty sand + gravel |
| BM2-0-0.5 | <16.8 | 181.5 | 122.1 | <46.8 | 768 | <65.85 | <48.9 | 1280 | <195 | <600 | <810 | 33177.6 | 1189.6 | 858.4 | 0-0.3 Tailings; 0.3-0.5 Native |
| BM3-0-0.8 | 22.5 | 147.2 | 126.8 | <45.15 | 79.6 | <37.5 | <48.75 | 2028.8 | <225 | <645 | <855 | 31692.8 | <1185 | 1340 | 0-0.3 lt tan silty sand; 0.3-0.8 brn silty sand + abund cobbles |
| BM4-0-1.0 | <16.95 | 126.9 | 88.4 | <53.1 | 2219.2 | 184.2 | <76.8 | 4758.4 | 412.8 | <660 | <900 | 37990.4 | 1449.6 | 1120 | Tailings lt tan silty sand w/clots of yw oxide |
| BM5-0-0.7 | <36.9 | <51 | 161.7 | <270 | 38195.2 | 1109.6 | 545.2 | 3520 | <1260 | 32793.6 | <3300 | 180940.8 | <4348.8 | 8307.2 | Tailings lt tan silty sand + minor yw clots |
| BM5-0.7-1.4 | <20.1 | 134.2 | 75.6 | <74.85 | 3718.4 | 234.2 | <79.2 | 585.2 | <375 | 4118.4 | <1274.4 | 60774.4 | <1650 | 2560 | Native mod oxid org sand + gravel + cobbles |
| BM6-0-0.7 | <17.7 | 147.5 | 120.9 | <49.2 | 90.1 | 257.8 | <46.65 | 515.6 | <225 | 1249.6 | <1005 | 46796.8 | 2529.6 | 858.4 | Tailings? Lt tan silty sand, no oxid |
| BM7-0-1.1 | 35 | 44.4 | 141.3 | <150 | 20096 | 670.4 | 395.6 | 1500 | <705 | 19200 | <1800 | 84480 | 3440 | 3948.8 | Tailings lt tan - yw tan w/thin 1" layer grnish gry clayey silt at bottom |
| BM7-1.1-1.6 | <20.1 | 87 | 135.1 | <57.75 | 1020 | 120.1 | <55.2 | 306.6 | <285 | 1260 | <1290 | 61081.6 | 3958.4 | 1009.6 | Native org silty sand + cobbles |
| BM9-0-1.0 | <22.2 | 78.7 | 135.6 | <111.6 | 10496 | <285 | 282.4 | 1060 | <540 | 12000 | <1484.4 | 70963.2 | 3268.8 | 3369.6 | Tailings + oxidized Native + abund cobbles |
| BM10-0-0.9 | <18.15 | 71.7 | 168 | <72.75 | 4428.8 | 350.6 | <84.45 | 579.6 | <270 | 1160 | <1185 | 58777.6 | 2920 | 726 | Native variable yw - org brn oxid w/abund gravel + cobbles |
| BM11-0-1.3 | <18.75 | 110.3 | 97.2 | <69 | 3840 | 195.7 | <77.4 | 517.2 | <270 | 1908.8 | <1065 | 49792 | 2329.6 | 2280 | Native mod oxid w/gravel + cobbles |
| BM11-1.3-1.7 | <18.6 | 120.6 | 83.8 | <53.7 | 1189.6 | 140.4 | 200.8 | 1169.6 | <510 | 17792 | <1005 | 39987.2 | 2908.8 | 2459.2 | Native soil choc brn silty sand + gravel |
| BM12-0-0.6 | <18.75 | 132 | 142 | <66.75 | 3788.8 | 248.6 | <80.85 | 1589.6 | <270 | 1489.6 | <1065 | 51686.4 | 1880 | 1828.8 | Tailings lt tan silty sand, no oxid |
| BM13-0-0.5 | <16.8 | 98.4 | 121.9 | <56.85 | 2339.2 | 134.6 | <75.15 | 2108.8 | <375 | 8684.8 | <885 | 34790.4 | 1600 | 1680 | Mixed Tailings + Native minor to mod oxid |
| BM14-0-0.5 | 19.9 | 134.1 | 157.2 | <71.55 | 5040 | 222 | <90.3 | 1640 | 355.2 | 905.6 | <1080 | 50995.2 | 3529.6 | 891.2 | Tailings lt tan w/variable yw brn FeOx |
| BM14-0.5-1.1 | <18 | 101.7 | 131.1 | <68.85 | 4748.8 | 287.2 | <80.85 | 722.4 | 316.2 | 950.4 | <1035 | 49689.6 | 2188.8 | 900.8 | Native choc brn silty sand + gravel + cobbles; sharp contact no oxid |
| BM15-0-1.2 | <18.75 | 78.2 | 97.8 | <66 | 2908.8 | 301.4 | <94.65 | 4649.6 | 410.4 | 1020 | <1065 | 44876.8 | 2000 | 1880 | Tailings yw brn - lt brn silty sand |
| BM17-0-0.9 | <16.8 | 82.7 | 74.4 | <62.85 | 3360 | 348.4 | <102.45 | 8588.8 | 500.4 | 5968 | <975 | 46592 | 2840 | 2539.2 | Tailings lt tan silty sand |
| BM18 | <23.25 | 77.5 | 111.6 | <96.3 | 5788.8 | <225 | 1109.6 | 2068.8 | <1005 | 55552 | <1650 | 79667.2 | 3040 | 3280 | WR 3 pt. rep composite on #1 bench mill foundation |
| BM19 | 33.1 | <38.4 | 212.6 | <210 | 37376 | 1480 | 630.8 | 1969.6 | 972 | 3497.6 | <2250 | 141926.4 | 7104 | 2609.6 | WR probably crushed ore, v. abund pyrite cubes in sand |
| 29-451-BM-1 | <22.8 | 90.3 | 143.7 | <119.55 | 10694.4 | <300 | <148.2 | 3379.2 | 619.6 | <1155 | <1500 | 64000 | <1950 | 923.2 | Composite of BM1-0-0.5; BM4-0-1.0; BM5-0-0.7 |
| 29-451-BM-2 | <23.85 | 83.5 | 131.2 | <119.4 | 8844.8 | 383.6 | <143.25 | 991.2 | <375 | <1110 | <1500 | 54579.2 | <2100 | <780 | Composite of BM7-0-1.1; BM10-0-0.9; BM14-0-0.5 |
| 29-451-BM-3 | <28.95 | 52.2 | 165.9 | <195 | 19392 | <495 | <225 | 2929.6 | <555 | <1650 | <2250 | 90265.6 | <3000 | 1180 | Composite of BM18; BM19 |
| 29-451-BM-1 | <23.25 | 87.3 | 116.6 | <133.5 | 13094.4 | <315 | <148.35 | 2520 | 605.2 | <1185 | <1650 | 71065.6 | <2100 | 1819.2 | rerun for precision check |
| 29-451-BM-3 | <26.25 | 37.4 | 150.6 | <165 | 20697.6 | <420 | <195 | 2979.2 | 1029.6 | <1454.4 | <1950 | 95283.2 | <2548.8 | 1509.6 | rerun for precision check |
| Mininum detected | 19.9 | 37.4 | 74.4 | 0 | 79.6 | 120.1 | 200.8 | 306.6 | 316.2 | 905.6 | 0 | 31692.8 | 1189.6 | 726 | |
| Maximum | 35 | 181.5 | 212.6 | 0 | 38195.2 | 1480 | 1109.6 | 8588.8 | 1029.6 | 55552 | 0 | 180940.8 | 7104 | 8307.2 | |
| Mean | 27.625 | 102.1 | 125.963 | 0 | 8586.078 | 397.2211 | 527.4 | 2026.6 | 580.1556 | 9973.553 | 0 | 64190.58 | 2833.929 | 2012.231 | |
| No. Samples | 4 | 25 | 27 | 0 | 27 | 19 | 6 | 27 | 9 | 17 | 0 | 27 | 17 | 26 | |
| | | | | | | | | | | | | | | | |
| BM4-1.0-1.5 | <15.6 | 118.1 | 90.9 | <42.9 | 56.8 | <32.4 | <37.2 | 773.2 | <165 | <465 | <615 | 18790.4 | <885 | 963.2 | Native; choc brn silty sand w/abund cobbles |

**Buckeye Mine Waste Rock WR1 and WR2 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WR1-A | 22.6 | 68.9 | <22.35 | <72.45 | 1920 | 241.2 | 540.8 | 1260 | <840 | 35891.2 | <1800 | 92569.6 | <2400 | 4240 | WR strongly oxid yw to red brn FeOx |
| WR1-B | <19.65 | 42.9 | 55.5 | <49.5 | 143.9 | <52.65 | <49.95 | 842.4 | <285 | 1340 | <1244.4 | 54784 | 3539.2 | 2009.6 | WR not as strongly oxidized |
| WR1-C | <19.8 | 75.3 | 32.8 | <69.45 | 1769.6 | 413.6 | <98.55 | 6739.2 | <375 | <1080 | <1470 | 77158.4 | 2760 | 1899.2 | WR biotite gneiss/schist w/qtz vein material |
| WR2-A | 24.8 | 42.8 | 118.7 | <55.8 | 328.4 | 77.9 | 148 | 1489.6 | <540 | 15091.2 | <1440 | 72652.8 | 2868.8 | 3369.6 | WR org brn FeOx fn-med sand |
| WR2-B | 22.5 | 49.4 | 61.1 | <66.75 | 2619.2 | 176.4 | <107.55 | 7680 | <345 | <915 | <1244.4 | 55449.6 | 2000 | 1948.8 | WR org brn FeOx fn-med sand |
| WR2-C | 19.3 | 87.6 | 79.4 | <50.4 | 402.2 | 129 | <53.55 | 742 | <270 | 1089.6 | <1170 | 57958.4 | 3049.6 | 1520 | WR org brn FeOx fn-med sand |
| 29-451-WR-1 | <23.1 | 98.7 | 51.2 | <79.5 | 2000 | 235.8 | <104.85 | 4137.6 | <390 | <1200 | <1650 | 72857.6 | 2329.6 | 1229.6 | Composite of WR2-B; WR1-A; WR2-C; WR1-C |
| Mininum detected | 19.3 | 42.8 | 32.8 | 0 | 143.9 | 77.9 | 148 | 742 | 0 | 1089.6 | 0 | 54784 | 2000 | 1229.6 | |
| Maximum | 24.8 | 98.7 | 118.7 | 0 | 2619.2 | 413.6 | 540.8 | 7680 | 0 | 35891.2 | 0 | 92569.6 | 3539.2 | 4240 | |
| Mean | 22.3 | 66.51429 | 66.45 | 0 | 1311.9 | 212.3167 | 344.4 | 3270.114 | 0 | 13353 | 0 | 69061.49 | 2757.867 | 2316.686 | |
| No. Samples | 4 | 7 | 6 | 0 | 7 | 6 | 2 | 7 | 0 | 4 | 0 | 7 | 6 | 7 | |

**Buckeye Mine Waste Rock WR3 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WR3-A | <18.9 | 70.3 | 55.9 | <57.3 | 832 | <82.2 | <65.4 | 1849.6 | <315 | <1005 | <1380 | 75673.6 | 3478.4 | 1960 | WR mod strong oxid |
| WR3-B | <18.6 | 28.1 | 80.7 | <42.45 | <57.9 | <42.3 | <42.6 | 161.9 | <330 | <1155 | <1650 | 89497.6 | 3427.2 | 1060 | WR mod strong oxid |
| WR3-C | <18.3 | 71.1 | 97.3 | <48.3 | <53.7 | <39.75 | <40.5 | <119.25 | <285 | 1120 | <1290 | 69990.4 | 2308.8 | 2889.6 | WR well vegetated, minor oxid |
| 29-451-WR-2 | <22.8 | 57.5 | 104.8 | <67.05 | 249.2 | <69.6 | <64.5 | 526 | <390 | 1720 | <1800 | 85350.4 | 3619.2 | 1480 | Composite of WR3-A; WR3-B; WR3-C |
| Mininum detected | 0 | 28.1 | 55.9 | 0 | 249.2 | 0 | 0 | 161.9 | 0 | 1120 | 0 | 69990.4 | 2308.8 | 1060 | |
| Maximum | 0 | 71.1 | 104.8 | 0 | 832 | 0 | 0 | 1849.6 | 0 | 1720 | 0 | 89497.6 | 3619.2 | 2889.6 | |
| Mean | 0 | 56.75 | 84.675 | 0 | 540.6 | 0 | 0 | 845.8333 | 0 | 1420 | 0 | 80128 | 3208.4 | 1847.4 | |
| No. Samples | 0 | 4 | 4 | 0 | 2 | 0 | 0 | 3 | 0 | 2 | 0 | 4 | 4 | 4 | |

**Buckeye Mine Waste Rock WR4 and Open Cut Waste Rock XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WR4-ORE | 337.4 | <145.8 | <240 | <1650 | <2848.8 | 4579.2 | 16896 | 12896 | <14995.2 | 785612.8 | <24000 | <LOD | <31488 | 63590.4 | |
| WR4-B-0-3.7 | <17.55 | <17.55 | 291.8 | <63.9 | 1549.6 | <103.5 | <57.15 | 361.8 | <270 | <855 | <1170 | 50483.2 | <1500 | 1640 | WR intense oxid org brn FeOx |
| WR4-B-3.7-5.7 | 20.4 | 51.4 | 99.2 | <58.35 | 479.6 | <68.1 | 136.2 | 1788.8 | <435 | 13388.8 | <750 | 20889.6 | <1290 | 4099.2 | WR mod oxid org brn FeOx |
| WR4-A | <18.3 | 33.4 | 138.8 | <72.6 | 3529.6 | <148.2 | <74.55 | 684.4 | <270 | <840 | <1140 | 47897.6 | <1500 | 2520 | WR intense oxid org brn FeOx |
| WR4-C-0-4.3 | <18.9 | 24.2 | 315 | <85.65 | 5868.8 | <195 | <99.45 | 2289.6 | 499.6 | <825 | <1110 | 46592 | <1500 | 2188.8 | WR intense oxid yw brn FeOx |
| WR4-C-4.3-5.9 | <19.35 | <22.95 | 262 | <110.25 | 12294.4 | 541.6 | <128.4 | 1449.6 | 310 | <810 | <1080 | 41395.2 | <1650 | 2708.8 | WR intense oxid yw brn FeOx |
| WR4-C-5.9-8.7 | <13.95 | 153.5 | 168.2 | <36.3 | 74.3 | <32.25 | 45.2 | 223 | <225 | 4867.2 | <510 | 16588.8 | <780 | 1569.6 | Native drk choc brn silty sand, nil FeOx |
| WR4-D-0-3.2 | 26.2 | 20.1 | 66.6 | <67.8 | 1689.6 | 181.1 | <79.05 | 1819.2 | <495 | 9529.6 | <1424.4 | 66457.6 | <1950 | 3840 | WR intensely oxid org brn |
| WR4-D-3.2-5.4 | 19.7 | 129.8 | 174.9 | <43.5 | 155.1 | <57.15 | <114.75 | 16691.2 | 574.4 | <585 | <765 | 24000 | 2200 | 1880 | Native choc brn silty sand |
| WR4-E-0-1.3 | <15.3 | 41.2 | 125.1 | <52.5 | 1920 | <94.05 | <52.35 | 634.4 | 268.4 | <705 | <960 | 50483.2 | <1244.4 | 1409.6 | WR intensely oxid org brn |
| 29-451-WR4-1 | <19.8 | 28.1 | 252.6 | <67.2 | 1609.6 | 142 | <66.3 | 737.6 | <300 | <960 | <1304.4 | 50892.8 | <1650 | <615 | Composite of WR4-B-0-3.7; WR4-D-0-3.2; WR4-E-0-1.3 |
| 29-451-WR4-2 | <22.8 | <26.7 | 170 | <126.45 | 9856 | 326.8 | <145.95 | 1589.6 | <315 | <885 | <1200 | 33280 | <1800 | 1609.6 | Composite of WR4-B-3.7-5.7; WR4-C-4.3-5.9 |
| 29-451-WR4-2 | <19.05 | <21.75 | 135.4 | <100.5 | 8275.2 | 392 | <120.3 | 985.6 | 269.4 | <720 | <960 | 24998.4 | <1290 | <555 | rerun for precision check |
| Mininum detected | 19.7 | 20.1 | 66.6 | 0 | 74.3 | 142 | 45.2 | 223 | 268.4 | 4867.2 | 0 | 16588.8 | 2200 | 1409.6 | |
| Maximum | 337.4 | 153.5 | 315 | 0 | 12294.4 | 4579.2 | 16896 | 16691.2 | 574.4 | 785612.8 | 0 | 66457.6 | 2200 | 63590.4 | |
| Mean | 100.925 | 60.2125 | 183.3 | 0 | 3941.817 | 1027.117 | 5692.467 | 3242.369 | 384.36 | 203349.6 | 0 | 39496.53 | 2200 | 7914.182 | |
| No. Samples | 4 | 8 | 12 | 0 | 12 | 6 | 3 | 13 | 5 | 4 | 0 | 12 | 1 | 11 | |

**Open Cut Waste Rock**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OCWR-1 | <17.1 | 55.5 | 162.6 | <74.1 | 3747.2 | <142.8 | <84.45 | 2868.8 | 823.2 | <705 | <945 | 39091.2 | 2219.2 | 1180 | WR strongly oxid w/yw brn FeOx |
| OCWR-2 | <16.05 | 60.7 | 63.3 | <66.9 | 4128 | <142.05 | 92.8 | 370.8 | 246.4 | 710.4 | <750 | 26291.2 | <1095 | 1420 | WR strongly oxid w/reddish brn FeOx |

**Buckeye Mine Waste Rock WR5 XRF Analytical Results**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WR5-A-0-1.8 | <18.6 | 52.8 | 274.4 | <69.75 | 2699.2 | <135 | <94.95 | 5468.8 | 567.6 | <1005 | <1364.4 | 67072 | <1800 | 2289.6 | WR strongly oxid |
| WR5-A-1.8-3.1 | <18.9 | 25.3 | 355.6 | <67.65 | 1449.6 | <108.75 | <93.6 | 6198.4 | 341.2 | <660 | <870 | 23193.6 | <1170 | 547.2 | Native? Drk gry v. sandy + gravel + rock |
| WR5-B | 29 | 31.6 | 305 | <121.95 | 7276.8 | <270 | 153.8 | 1009.6 | <795 | 20889.6 | <2100 | 102963.2 | <2700 | 5078.4 | WR silt + clay runoff collected in small basin top of pile |
| WR5-C-0-2.0 | 21 | 78.1 | 138.2 | <76.35 | 3160 | <143.7 | <84 | 1589.6 | <450 | 9728 | <1110 | 44288 | <1500 | 2659.2 | WR strongly oxid yw to org brn; milky qtz + gry vnlts |
| WR5-D-0-2.0 | <19.05 | 42.2 | 153.1 | <71.7 | 3468.8 | <147.15 | <73.35 | 618.8 | 452 | <900 | <1215 | 56576 | <1650 | 3369.6 | WR strongly oxid yw to org brn |
| WR5-E-0-2.0 | <15 | 21.9 | 99.5 | <60.45 | 3539.2 | 322 | <78.9 | 4528 | 732.8 | 3120 | <975 | 51891.2 | <1274.4 | 2200 | WR strongly oxid yw to org brn; inc fines |
| WR5-F-0-2.0 | <19.35 | 38.1 | 98 | <79.65 | 4259.2 | <165 | 104 | 570 | <510 | 12396.8 | <1244.4 | 53452.8 | <1650 | 1249.6 | WR strong org brn FeOx; mod qtz vein material |
| 29-451-WR5-1 | <21.45 | 59.1 | 166.3 | <80.25 | 2828.8 | <165 | <98.25 | 2689.6 | <330 | <960 | <1304.4 | 46899.2 | <1800 | 1120 | Composite of WR5-A-0-1.8; WR5-C-0-2.0; WR5-E-0-2.0 |
| 29-451-WR5-2 | <23.7 | 60.7 | 153.4 | <89.55 | 3708.8 | <195 | <95.4 | 532.4 | 418.8 | <1020 | <1380 | 48076.8 | <1800 | 1189.6 | Composite of WR5-D-0-2.0; WR5-A-0-2.0 |
| Mininum detected | 21 | 21.9 | 98 | 0 | 1449.6 | 322 | 104 | 532.4 | 341.2 | 3120 | 0 | 23193.6 | 0 | 547.2 | |
| Maximum | 29 | 78.1 | 355.6 | 0 | 7276.8 | 322 | 153.8 | 6198.4 | 732.8 | 20889.6 | 0 | 102963.2 | 0 | 5078.4 | |
| Mean | 25 | 45.53333 | 193.7222 | 0 | 3598.933 | 322 | 128.9 | 2578.356 | 502.48 | 11533.6 | 0 | 54934.76 | 0 | 2189.244 | |
| No. Samples | 2 | 9 | 9 | 0 | 9 | 1 | 2 | 9 | 5 | 4 | 0 | 9 | 0 | 9 | |

**Borrow Source Cover Soil**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BS-2-0-11.7 | <17.25 | 171.8 | 147.2 | <44.4 | <45.75 | <32.7 | <29.85 | 94 | <150 | <465 | <630 | 17689.6 | <870 | 847.2 | Borrow source soil; 0-0.4 topsoil; lt brn fn sandy silt; some clots clayey |
| BS-3-0-11.9 | <98.4 | 194.7 | 171.4 | <300 | <345 | <195 | <210 | <360 | <735 | <2548.8 | <3600 | 13299.2 | <4948.8 | <1650 | Borrow source soil; 0-0.6 topsoil; lt brn fn sandy silt; slight moist >4' |
| BS-4-0-3.4 | <22.65 | 183.1 | 157.8 | <59.55 | <61.95 | <44.55 | <45.9 | <101.7 | <195 | <555 | <735 | 13593.6 | <960 | <405 | Borrow source soil; lt brn sandy silt |
| BS-5-3.6-6.3 | <21.3 | 184.6 | 188.7 | <52.2 | <51.6 | <36.6 | <36 | <88.95 | <165 | <525 | <705 | 15296 | <960 | 460 | Borrow source soil; coarse sand + gravel; oxidized |
| BS-5-0-3.6 | <22.5 | 67.8 | 502.8 | <68.4 | <71.7 | <50.85 | <57 | <180 | <390 | 3849.6 | <1185 | 33484.8 | <1500 | 868.8 | Borrow source soil; 0-0.5 topsoil; lt brn sandy clay |
| BS-4-3.4-4.8 | <23.4 | 44 | 470 | <64.95 | <72.15 | <50.7 | <46.05 | <139.2 | <285 | <900 | <1215 | 34278.4 | <1650 | 1659.2 | Borrow source soil; coarse sand; slightly oxidized; bedrock @4.8 |
| 29-451-BS-1 | <22.05 | 149.6 | 247.8 | <63 | <31.2 | <46.2 | <47.25 | <111.3 | <210 | <630 | <855 | 18598.4 | <1155 | <480 | Composite of BS-1-0-4.0; BS-5-0-3.6; BS-4-0-3.4 |
| 29-451-BS-2 | <19.2 | 184.8 | 172.7 | <51.6 | <65.25 | <35.55 | <34.5 | <85.65 | <165 | <495 | <675 | 15795.2 | <960 | 512.4 | Composite of BS-2-0-11.7; BS-3-0-11.9; BS-5-3.6-6.3 |
| Mininum detected | 0 | 44 | 147.2 | 0 | 0 | 0 | 0 | 94 | 0 | 3849.6 | 0 | 13299.2 | 0 | 460 | |
| Maximum | 0 | 194.7 | 502.8 | 0 | 0 | 0 | 0 | 94 | 0 | 3849.6 | 0 | 34278.4 | 0 | 1659.2 | |
| Mean | 0 | 147.55 | 257.3 | 0 | 0 | 0 | 0 | 94 | 0 | 3849.6 | 0 | 20254.4 | 0 | 869.52 | |
| No. Samples | 0 | 8 | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 8 | 0 | 5 | |

**Background Soil**

| Sample ID | Mo | Zr | Sr | Rb | Pb | As | Hg | Zn | Cu | Ni | Co | Fe | Mn | Cr | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-451-BG-1 | <18.15 | 172.6 | 107.6 | <45.6 | <52.95 | <35.55 | <38.25 | <106.8 | <225 | 1939.2 | <720 | 22297.6 | 1189.6 | 1549.6 | Background soil |
| 29-451-BG-2 | <17.4 | 95.2 | 70.1 | <47.55 | <45.75 | <36.9 | <38.1 | <121.8 | <270 | 2169.6 | <1035 | 46284.8 | <1454.4 | 1908.8 | Background soil |
| 29-451-BG-3 | <17.4 | 138.7 | 97.4 | <43.35 | 103.1 | <39.9 | <36.15 | 177 | <225 | 1480 | <765 | 25792 | <1125 | 1659.2 | Background soil |
| 29-45-BG-4 | | | | | | | | | | | | | | | Background soil - not analyzed via XRF |
| 29-45-BG-5 | | | | | | | | | | | | | | | Background soil - not analyzed via XRF |
| Mininum detected | 0 | 95.2 | 70.1 | 0 | 103.1 | 0 | 0 | 177 | 0 | 1480 | 0 | 22297.6 | 1189.6 | 1549.6 | |
| Maximum | 0 | 172.6 | 107.6 | 0 | 103.1 | 0 | 0 | 177 | 0 | 2169.6 | 0 | 46284.8 | 1189.6 | 1908.8 | |
| Mean | 0 | 135.5 | 91.7 | 0 | 103.1 | 0 | 0 | 177 | 0 | 1862.933 | 0 | 31458.13 | 1189.6 | 1705.867 | |
| No. Samples | 0 | 3 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 3 | 0 | 3 | 1 | 3 | |

# APPENDIX B

# DESCRIPTION OF FEDERAL AND STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

## Table of Contents

# 1.0 INTRODUCTION

This description of the applicable or relevant and appropriate requirements (ARARs) was compiled from documents describing ARARs for abandoned mine sites that was produced by the Montana Department of Environmental Quality (DEQ) - Mine Waste Cleanup Bureau (MWCB) and other state agencies. These ARARs, along with those prepared by ARCO for the Streamside Tailings Operable Unit (ARCO, 1995) and the Montana DEQ Hazardous Waste Site Cleanup Bureau for mine sites were reviewed and updated by Olympus to develop a listing of potential Federal and State ARARs for the Buckeye Mine Site.

Section 121(d)(2) of the CERCLA, 42 United States Code (U.S.C.) § 9621(d)(2), requires that clean-up actions conducted under CERCLA achieve a level or standard of control which at least attains "any standard, requirement, criteria, or limitation under any Federal environmental law... or any [more stringent] promulgated standard, requirement, criteria or limitation under a State environmental or facility siting law... [which] is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release of such hazardous substance or pollutant, or contaminant..." The standards, requirements, criteria, or limitations identified pursuant to this section are commonly referred to as "applicable or relevant and appropriate requirements (ARARs)."

Two general types of clean-up actions are recognized under CERCLA: removal actions and remedial actions. A removal action is an action to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or threat of release. This action is often temporarily taken to alleviate the most acute threats or to prevent further spread of contamination until more comprehensive action can be taken. A remedial action is a thorough investigation, evaluation of alternatives, and determination and implementation of a comprehensive and fully protective remedy for the site.

ARARs may be either "applicable" or "relevant and appropriate" to remedial activities at a site but not both. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. A remedial action must satisfy all the jurisdictional prerequisites of a requirement for it to be applicable to the specific remedial action at a CERCLA site.

Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Factors which may be considered in making this determination, when the factors are pertinent, are presented in 40 Code of Federal Regulations (CFR) § 300.400(g)(2). They include, among other considerations, examination of the purpose of the requirement and of the CERCLA action, the medium and substances regulated by the requirement and at the CERCLA site, the actions or activities regulated by the requirement and the remedial action contemplated at the site, and the potential use of resources affected by the requirement and the use or potential use of the affected resource at the CERCLA site.

ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific requirements govern the release of materials possessing certain chemical or physical characteristics or containing specific chemical compounds into the environment. Contaminant-specific ARARs generally set human or environmental risk-based criteria and protocol which, when applied to site-specific conditions, result in the establishment of numerical action values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of site contaminants. These ARARs place restrictions on the concentration of hazardous substances or the conduct of clean-up activities due to their location in the environment.

Action-specific ARARs are usually technology- or activity-based requirements or are limitations on actions taken with respect to hazardous substances. A particular remedial activity will trigger an action-specific ARAR. Unlike chemical- and location-specific ARARs, action-specific ARARs do not, in themselves, determine the remedial alternative. Rather, action-specific ARARs indicate how the selected remedy must be achieved.

Non-promulgated advisories or guidance documents issued by federal or state governments do not have the status of potential ARARs. However, these advisories and guidance documents are "To Be Considered (TBC)" when determining protective clean-up levels. The TBC category consists of advisories, criteria, or guidance that were developed by the U.S. Environmental Protection Agency (EPA), other federal agencies, or states that may be useful in developing CERCLA remedies. These categories may be considered as appropriate in selecting and developing clean-up actions.

As provided by Section 121 of CERCLA, 42 U.S.C. § 9621, only those state standards that are more stringent than any federal standard and that have been identified by the State in a timely manner are appropriately included as ARARs. Some state standards that are potentially duplicative of federal standards are identified here to ensure their timely identification and consideration in the event that they are not identified or retained in the federal ARARs. Duplicative or less stringent standards will be deleted as appropriate when the final determination of ARARs is presented.

CERCLA defines only federal environmental laws and state environmental or facility siting laws as ARARs. Remedial design, implementation, and operation and maintenance must, nevertheless, comply with all other applicable laws, both state and federal. Many such laws, while not strictly environmental or facility siting laws, have environmental impacts. Moreover, applicable laws that are not ARARs because they are not environmental or facility siting laws are not subject to the ARAR waiver provisions, and the administrative, as well as the substantive, provisions of such laws must be observed. A separate list attached to the state ARARs' list is a non-comprehensive identification of other state law requirements, which must be observed during remedial design, remedy implementation, operation, or maintenance.

The description of the federal (Section 2.0) and state (Section 3.0) ARARs that follows includes summaries of legal requirements that in many cases attempt to set out the requirement in a simple fashion useful in evaluating compliance with the requirement. In the event of any inconsistency between the law itself and the summaries in this section, the ARAR is ultimately the requirement as set out in the law, rather than any paraphrase provided here.

The potential Federal and State ARARs, advisories, and guidance that may be useful in reclaiming the Buckeye Mine Site are presented below in the following sections.

# 2.0 FEDERAL ARARS

Potential federal ARARs for the Buckeye Mine Site are presented below.

## 2.1 FEDERAL CONTAMINANT-SPECIFIC ARARS

### 2.1.1 Clean Water Act (Applicable)

The Federal Clean Water Act (33 U.S.C. §§ 1251-1375) as amended by the Water Quality Act of 1987 (Public Law 100-4 § 103) provides the authority for each state to adopt water quality standards (40 CFR Part 131) designed to protect beneficial uses of each water body and requires each state to designate uses for each water body. EPA regulation requires states to establish antidegradation requirements. EPA has provided guidance to the states for this purpose ("Water Quality Criteria Summary"; Quality Criteria for Water 1986 - Update 2 EPA; May 1, 1987). Pursuant to this authority and the criteria established by Montana water quality regulations (ARM § 17.30.623), Montana established classification standards for discharge into the major river drainages. These classifications are presented in the state ARARs section.

At this time, EPA is relying on the State standards. EPA reserves the right to identify federal water quality criteria as ARARs for this action, if appropriate.

40 CFR Part 122 establishes the National Pollutant Discharge Elimination System (NPDES). The substantive requirements of general permits for storm water discharges from construction are relevant and appropriate. See 57 Fed. Reg. 41236, September 9, 1992. Montana has an EPA approved State program (MPDES) that is discussed in the state ARARs section.

### 2.1.2 Safe Drinking Water Act (Relevant and Appropriate)

The Safe Drinking Water Act (SDWA) cited at 42 U.S.C. § 300f, et seq. has established the maximum contaminant levels (MCL) for chemicals in drinking water distributed in public water systems. The MCLs are contained in the national Primary and Secondary Drinking Water Regulations (40 CFR Parts 141 and 143). SDWA MCLs are not applicable to the reclamation activities at the site because the groundwater and surface water at the site are not a public water supply. The SDWA MCLs are relevant and appropriate at the site even though the groundwater and surface water are not currently part of a public water system because 26 private wells have been identified within approximately 1 mile radius of the site and are located in Sections 19, 20, 29 and 30 Township 4 South and Range 4 West, Montana Principal Meridian. The Preamble to the National Oil and Hazardous Substance Contingency Plan (NCP) clearly states that the MCLs are relevant and appropriate for groundwater that is a current or potential source of drinking water (55 Fed. Reg. 8750 (March 8, 1990)) and is further supported by requirements of the NCP, 40 CFR, § 300.430(e)(2)(i)(B). MCLs developed under the SDWA generally are ARARs for current or potential drinking water sources.

Standards for potential contaminants of concern at the site are:

| Element | MCLs[a] (mg/L) | MT Human Health Standard[b] Surface Water (ug/L) | Groundwater (ug/L) |
|---|---|---|---|
| Antimony | 0.006 | 6 | 6 |
| Arsenic | 0.05 [c] | 18 | 20 |
| Cadmium | 0.005 | 5 | 5 |
| Copper | 1.3 | 1,300 | 1,300 |
| Lead | 0.015 | 15 | 15 |
| Manganese | 0.05 | 50 | 50 |
| Mercury | 0.002 | 0.05 | 2 |
| Silver | 0.1 | 100 | 100 |
| Zinc | 5 | 2,000 | 2,000 |

Note: [a] = Federal Primary and Secondary Maximum Contaminant Levels in Water
[b] = DEQ WQB Circular WQB-7 (January 2002)
[c] = 0.010 mg/L as of 1/23/06

The EPA has granted to the State of Montana primacy in the implementation and enforcement of the Safe Drinking Water Act (SDWA). Thus, the law commonly enforced in Montana is the state law. The state regulations substantially parallel the federal law.

### 2.1.3 Clean Air Act (Applicable)

Section 109 of the Clean Air Act (42 U.S.C. § 7409) and implementing regulations found at 40 CFR Part 50 set national primary and secondary ambient air quality standards. National primary ambient air quality standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health. National secondary ambient air quality standard define levels of air quality that are necessary to protect public welfare from any known or anticipated adverse effects of a pollutant. The standards for particulate matter at 40 CFR § 50.6 are applicable for reclamation alternatives for the Buckeye Mine Site, particularly for the earth moving (load, haul, dump), grading, and capping activities. These standards must be met both during the design and implementation phases of the remedial action.

Particulate Matter

The ambient air quality standard for particulate matter of less than or equal to 10 micrometers in diameter (PM-10) is 150 micrograms per cubic meter, 24-hour average concentration; 50 micrograms per cubic meter, annual arithmetic mean for particulate matter of less than or equal to 10 micrometers in diameter.

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the 30-day average of 10 grams per square meter. Administrative Rules of Montana (ARM) § 17.8.220 (applicable).

### 2.1.4 Resource Conservation and Recovery Act (Applicable)

Under 40 CFR Part 261, Subpart A defines the solid wastes (mining-related wastes) which are subject to regulations as hazardous wastes. This requirement is applicable to reclamation alternatives that involve treatment, storage, or disposal of hazardous wastes in a solid waste management unit (such as a surface impoundment, waste pile, land treatment unit, or landfill). The limits specified for ground water protection are the same as the maximum contaminant levels (MCL) for those substances as defined in Section 2.1.2.

## 2.2 FEDERAL LOCATION-SPECIFIC ARARS

### 2.2.1 National Historic Preservation Act (Applicable)

This statute, and implementing regulations (16 U.S.C. § 470, 40 CFR § 6.301(b), 36 CFR Part 800), requires federal agencies or federal projects to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in, or eligible for, the Register of Historic Places. Compliance with this ARAR requires consultation with the State Historic Preservation Officer (SHPO), who can identify historic properties and assess whether proposed clean-up actions will impact these resources.

### 2.2.2 Archeological and Historical Preservation Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 469, 40 CFR § 6.301 (c)) establish requirements for the evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of a Federal construction project or a federally licensed activity or program. This requires a survey of the site for covered scientific, prehistorical or archaeological artifacts. Preservation of appropriate data concerning the artifacts is hereby identified as an ARAR requirement, to be completed during the implementation of the reclamation activities.

### 2.2.3 Historic Sites, Buildings and Antiquities Act (Applicable)

This Act (16 U.S.C. §§ 461 <u>et</u> <u>seq</u>.; 40 CFR § 6.301(a)) states that "in conducting an environmental review of a proposed EPA action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts upon such landmarks." "National natural landmarks" are defined under 36 CFR § 62.2 as:

> National Natural Landmark is an area designated by the Secretary of the Interior as being of national significance to the United States because it is an outstanding example(s) of major biological and geological features found within the boundaries of the United States or its Territories or on the Outer Continental Shelf

Under the Historic Sites Act of 1935, the Secretary of the Interior is authorized to designate areas as National Natural Landmarks for listing on the National Registry of Natural Landmarks.

### 2.2.4 Protection of Wetlands Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,990) mandates that Federal agencies and the Potentially Responsible Party (PRP) avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Wetlands are defined as those areas that are inundated or saturated by groundwater or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. For this project, jurisdictional wetland identification has not been performed. Other than Mill Creek flowing through the southern portion of the project, the site characterization work did not identify any obvious wetlands associated with Mill Creek or springs within the immediate project area. Compliance with this ARAR requires consultation with the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service to determine the extent of wetlands and to ascertain the means and measures necessary to mitigate, prevent, and compensate for project related losses of wetlands.

### 2.2.5 Floodplain Management Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandates that federally funded or authorized actions within the 100-year floodplain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain. Compliance with this requirement is detailed in "Policy on Floodplains and Wetland Assessments for CERCLA Actions," 1985. Specific measures to minimize adverse impacts will be identified following consultation with the appropriate agencies. The Buckeye Mine Site is not located within a designated 100-year floodplain.

### 2.2.6 Fish and Wildlife Coordination Act (Applicable)

This standard (16 U.S.C. §§ 661 et seq., 40 CFR § 6.302(g)) requires that Federal agencies or federally funded projects ensure that any modification of any stream or other water body affected by an action authorized or funded by the Federal agency provides for adequate protection of fish and wildlife resources. Compliance with this ARAR requires consultation with the U.S. Fish and Wildlife Service and the Wildlife Resources Agency of the affected state (State of Montana Department of Fish, Wildlife, and Parks) to ascertain the means and measures necessary to mitigate, prevent, and compensate for project-related losses of wildlife resources and to enhance the resources. Consultation will occur during the public comment period, and specific mitigative measures may be identified in consultation with the appropriate agencies, if alternatives, as developed, will affect a stream.

### 2.2.7 Endangered Species Act (Applicable)

This statute, and implementing regulations (16 U.S.C. §§ 1531 et seq., 50 CFR § 402 and 40 CFR § 6.302(h)), require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat. Compliance with this requirement involves consultation with the U.S. Fish and Wildlife Service, resulting in a determination as to whether there are listed or proposed species or critical habitats present, and, if so, whether any proposed activities will impact such wildlife or habitat. At this time no threatened or endangered species or critical habit has been identified on the Buckeye Mine site. Threatened and endangered species that can be found on the Madison District of the Beaverhead-Deerlodge National Forest are the threatened grizzly bear and bald eagle (proposed for delisting), nonessential experimental gray wolf, threatened Canada lynx, and proposed threatened mountain plover. Currently in the Tobacco

Root Mountains, there are no bald eagle nests, no mountain plovers, and only occasional sightings of grizzly bears, gray wolves, and lynx (USFS, 2001). Sensitive species that are known to occur in the Tobacco Root Mountains are the wolverine, northern goshawk, and black-backed woodpecker.

### 2.2.8 Resource Conservation and Recovery Act (Relevant and Appropriate)

The requirements set forth at 40 CFR § 264.18(a) and (b) provide that: a) any hazardous waste facility must not be located within 61 meters (200 feet) of a fault; and b) any hazardous waste facility within the 100-year floodplain must be designed, constructed, operated and maintained to avoid washout. Any discrete disposal or storage facilities which remain on-site as part of the remedial alternative must meet these standards.

## 2.3 FEDERAL ACTION-SPECIFIC ARARS

### 2.3.1 Surface Mining Control and Reclamation (Relevant and Appropriate)

This Act (30 U.S.C. §§ 1201-1328) and implementing regulations found at 30 CFR Parts 816 and 784 establish provisions designed to protect the environment from the effects of surface coal mining operations, and to a lesser extent, non-coal mining. The regulations require that revegetation be used to stabilize soil covers over reclaimed areas. These requirements are relevant and appropriate to the covering of discrete areas of contamination. They also require that revegetation be done according to a plan which specifies schedules, species which are diverse and effective, planting methods, mulching techniques, irrigation if appropriate, and appropriate soil testing. Reclamation performance standards are currently relevant and appropriate to mining waste sites.

### 2.3.2 Clean Water Act (Applicable)

40 CFR Part 122 establishes the National Pollutant Discharge Elimination System (NPDES). The substantive requirements of general permits for storm water discharges from construction are relevant and appropriate. See 57 Fed. Reg. 41,236, September 9, 1992. Montana has an EPA approved State program (MPDES) that is discussed in the State ARARs Section.

### 2.3.3 Resource Conservation and Recovery Act

Criteria for Classification of Solid Waste Disposal Facilities Practices (Applicable)

The criteria contained in 40 CFR Part 257 (Subtitle D) are used in accordance with RCRA guidance in determining which practices pose a reasonable probability of having an adverse effect on human health or the environment. RCRA Subtitle D establishes criteria which are, for the most part, environmental performance standards that are used by states to identify unacceptable solid waste disposal practices or facilities.

Regulation 40 CFR Part 257.3-1(a) states that facilities or practices in the floodplain shall not result in the washout of solid waste so as to pose a hazard to human life, wildlife, or land or water resources.

Regulation 40 CFR Part 257.3-2 provides for the protection of threatened or endangered species.

40 CFR Part 257.3-3 provides that a facility shall not cause the discharge of pollutants into waters of the United States; this includes dredged or fill materials.

40 CFR Part 257.3-4 states that a facility or practice shall not contaminate underground drinking water beyond the solid waste boundary.

Standards Applicable to Transporters of Hazardous Waste (Applicable)

The regulations at 40 CFR Part 263 establish standards that apply to persons that transport hazardous waste within the U.S. If hazardous waste is transported on a rail-line or public highway on-site, or if transportation occurs off-site, these regulations will be relevant and appropriate.

Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Relevant and Appropriate)

A. Releases from Solid Waste Management Units (Applicable)

The regulations at 40 CFR 264, Subpart F, establish requirements for groundwater protection for RCRA-regulated solid waste management units (i.e., waste piles, surface impoundments, land treatment units, and landfills). Subpart F provides for three general types of groundwater monitoring: detection monitoring, compliance monitoring and corrective action monitoring. Monitoring is required during the active life of a hazardous waste management unit. At closure, if all hazardous waste, waste residue, and contaminated subsoil is removed, no monitoring is required. If hazardous waste remains, the monitoring requirements continue during the 40 CFR § 264.117 closure period.

B. Closure and Post-Closure (Relevant and Appropriate)

40 CFR Part 264, Subpart G, establishes that hazardous waste management facilities must be closed in such a manner as to: a) minimize the need for further maintenance; and b) control, minimize or eliminate, to the extent necessary, to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated run-off or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.

Facilities requiring post-closure care must undertake appropriate monitoring and maintenance actions, control public access, and control post-closure use of the property to ensure that the integrity of the final cover, liner, or containment system is not disturbed. 40 CFR § 264.117. In addition, all contaminated equipment, structures and soil must be properly disposed of or decontaminated unless exempt. 40 CFR § 264.114. A survey plat should be submitted to the local zoning authority and to the EPA Regional Administrator indicting the location and dimensions of landfill cells or other hazardous waste disposal units with respect to permanently surveyed benchmarks. 40 CFR § 264.116. 40 CFR § 264.228(a) requires that at closure, free liquids must be removed or solidified, the wastes stabilized, and the waste management unit covered.

C. Waste Piles (Applicable)

40 CFR Part 264, Subpart L, applies to owners and operators of facilities that store or treat hazardous waste in piles. The regulations require the use of run-on and run-off control systems and collection and hold systems to prevent the release of contaminants from waste piles.

D. Land Treatment (Applicable)

The requirements of 40 CFR Part 264, Subpart M, regulate the management of "land treatment units" that treat or dispose of hazardous waste; these requirements are applicable for any land treatment units established at the site. The owner or operator of a land treatment unit must design treatment so that hazardous constituents placed in the treatment zone are degraded, transformed, or immobilized within the treatment zone. "Hazardous constituents" are those identified in Appendix VIII of 40 CFR Part 261 that are reasonably expected to be in, or derived from, waste placed in or on the treatment zone. Design measures and operating practices must be set up to maximize the success of degradation, transformation, and immobilization processes. The treatment zone is the portion of the unsaturated zone below and including the land surface in which the owner or operator intends to maintain the conditions necessary for effect degradation, transformation, or immobilization of hazardous constituents. The maximum depth of the treatment zone must be no more than 1.5 meters (5 feet) from the initial soil surface and more than one meter (3 feet) above the seasonal high water table.

Subpart M also requires the construction and maintenance of control features that prevent the run-off of hazardous constituents and the run-on of water to the treatment unit. The unit must also be inspected weekly and after storms for deterioration, malfunctions, and improper functioning of wind dispersal control measures.

An unsaturated zone monitoring program must be established to monitor soil and soil-pore liquid to determine whether hazardous constituents migrate out of the treatment zone. Specifications related to the monitoring program are contained in section 264.278. There are no land treatment units proposed for the Buckeye Mine Site.

E. Landfills

Regulation 40 CFR Part 264, Subpart N, applies to entities that dispose of hazardous waste in landfills. The regulations specify appropriate liner systems and leachate collection systems for landfills, run-on and run-off management systems, and wind dispersal controls for landfills. These regulations set forth specific requirements for landfill monitoring and inspection, surveying and recordkeeping, and closure and post-closure care. There are no landfills proposed for the Buckeye Mine Site.

### 2.3.4 Hazardous Materials Transportation Act (Applicable)

The Hazardous Materials Transportation Act (49 U.S.C. §§ 5101-5105), as implemented by the Hazardous Materials Regulations (49 CFR Parts 10, 171-177), regulates the transportation of hazardous materials. The regulations apply to any alternatives involving the transport of hazardous waste off-site, on public highways on-site, or by rail.

### 2.4 OTHER FEDERAL LAWS

#### 2.4.1 Occupational Safety and Health Regulations

The federal Occupational Safety and Health Act (29 USC § 655) regulations found at 29 CFR § 1910 are applicable to worker protection during conduct of RI/FS or remedial activities at hazardous material sites.

## 3.0 STATE OF MONTANA ARARS

Potential state ARARs for the Buckeye Mine Site are presented below.

### 3.1 MONTANA CONTAMINANT-SPECIFIC ARARS

#### 3.1.1 Montana Water Quality Act (Applicable)

Under the state Water Quality Act, §§ 75-5-101 et seq., MCA, the state has promulgated regulations to preserve and protect the quality of surface waters in the state. These regulations classify state waters according to quality, place restrictions on the discharge of pollutants to state waters and prohibit the degradation of state waters. The requirements listed below are applicable water quality standards with which any remedial action must comply.

ARM 17.30.610(1) (Applicable) provides that specified waters in the Missouri River drainage basin which includes the Mill Creek drainage are classified B-1 for water use.

The standards for B-1 classification waters are contained in ARM 17.30.623 (Applicable) of the Montana Water Quality regulations. These standards place limits on fecal coliform content, dissolved oxygen concentration, pH balance, turbidity, water temperature, sediments, solids, oils, and color. Concentrations of toxic and deleterious substances which would remain in the water after conventional treatment cannot exceed MCLs, and concentrations of toxic and deleterious substances cannot exceed Gold Book levels. The B-1 classification standards also provide:

- During periods when the daily maximum water temperature is greater than 60°F, the geometric mean number of organisms in the fecal coliform group must not exceed 200 per 100 milliliters (ml), nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliform per 100 ml.
- Dissolved oxygen concentration must not be reduced below the levels given in department Circular WQB-7.
- Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.
- The maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units except as permitted in ARM 17.30.637.

- Temperature variations are specifically limited, depending upon the temperature range of the receiving water.

- No increases are allowed above naturally occurring concentrations of sediment, settable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

- True color must not be increased more than five units above naturally occurring color.

- Concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters which would remain in the water after conventional water treatment may not exceed the applicable standards set forth in department Circular WQB-7.

Additional restrictions on any discharge to surface waters are included in:

ARM 17.30.635 (Applicable) requires that industrial waste must receive, as a minimum, treatment equivalent to the best practicable control technology currently available (BPCTCA) as defined in 40 CFR Subchapter N and subsequent amendments. Industrial waste is defined as any waste substance from the process of business or industry or from the development of any natural resource, together with any sewage that may be present, Section 75-5-103, MCA. This section also requires that in designing a disposal system, stream flow dilution requirements must be based on the minimum consecutive 7-day average flow which may be expected to occur on the average of once in 10 years.

ARM 17.30.637 (Applicable), which prohibits discharges containing substances that will:

(a) settle to form objectionable sludge deposits or emulsions beneath the water's surface or upon adjoining shorelines;

(b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;

(c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;

(d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; and

(e) create conditions which produce undesirable aquatic life.

ARM 17.30.637 also provides that leaching pads, tailing ponds, or water, waste, or product holding facilities must be located, constructed, operated, and maintained to prevent any discharge, seepage, drainage, infiltration, or flow which may result in pollution of state waters, and a monitoring system may be required to ensure such compliance. No pollutants may be discharged and no activities may be conducted which, either alone or in combination with other wastes or activities, result in the total dissolved gas pressure relative to the water surface exceeding 110 percent of saturation.

In determining ARARs, one should check the "prohibitions" set out in 17.30.637 for any site specific prohibitions.

ARM 17.30.501-518 provides that discharges to surface water or groundwater may be granted a mixing zone on a case by case basis by the DEQ in accordance with its written implementation policy and restrictions.

ARM 17.30.1345 (Applicable), adopts and incorporates the provisions of 40 CFR Part 125.3 for criteria and standards of the imposition of technology-based treatment requirements in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125.3 are applicable (i.e., for toxic and non-conventional pollutants). Treatment must apply the best available technology (BAT) economically achievable and, for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology-based treatment requirements are determined on a case-by-case basis using best professional judgment (BPJ). <u>See</u> CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p.3-4 and 3-7.

The Water Quality Act and regulations also include non-degradation provisions which require that waters which are of higher quality than the applicable classification be maintained at that high quality, and discharges which would degrade that water are prohibited. Montana's standard for non-degradation of water quality is applicable for all constituents for which pertinent portions of the Mill Creek drainage are of higher quality than the B-1 classification. If any remedial action constitutes a new source of pollution or an increased source of pollution, the non-degradation standard requires the degree of waste treatment necessary to maintain the existing water quality of constituents that are of higher quality than the applicable classification.

ARM 17.30.702 and 705 (Applicable) defines "degradation" and applies non-degradation requirements to any activity of man which would cause a new or increased source of pollution to state waters.

ARM 17.30.706-708 (Applicable) establishes the informational requirements for nondegradation significance/authorization review and department procedures for nondegradation review and decisions.

ARM 17.30.715-717 (Applicable) establishes criteria for determining nonsignificant changes in water quality, categories of activities that cause nonsignificant changes in water quality, and the requirement for implementation of water quality protection practices.

The MPDES permit requirements are technically not applicable to remedial actions at CERCLA sites because ARM 17.30.1310(3) exempts "Any discharge in compliance with the instructions of an on-scene coordinator pursuant to 40 CFR Part 300 <u>et</u> <u>seq</u>. (the NCP)." This exemption is even broader than the 121(e) permit exemption, because it would apply even to an off-site discharge, if such discharge were "in compliance with the instructions of the OSC." The MPDES requirements could still be relevant and appropriate to discharges of pollutants as part of a remedial action. However, it would be probably be more appropriate to identify the federal requirements as the relevant and appropriate requirements because of the express state exemption, which arguably represents a determination that the state MPDES requirements are not relevant or appropriate. Note that this analysis does not apply to a site being addressed only under CECRA and not CERCLA, because the exemption applies only to the instructions of an OSC under the NCP.

The MPDES standards (the substantive requirements to be enforced through the permitting process) are set out in 17.30.1203-1209. These standards are all simply incorporations of the federal regulations.

### 3.1.2 Montana Water Use Act

Montana Groundwater Pollution Control System (Applicable)

ARM 17.30.1006 (Applicable) classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and establishes groundwater quality standards applicable with respect to each groundwater classification. Groundwater classifications are based on natural specific conductance (ARM 17.30.1005). Class I is the highest quality class; class IV the lowest. ARM 17.30.1006 provides that Class I groundwaters have a specific conductance (SC) of less than or equal to 1,000 microSiemens/cm at 25° C. The SC of groundwater at the Buckeye Mine Site is unknown for there are no ground water wells or flowing adits available for monitoring specific conductance within the site boundary. However, water tested in two private wells located immediately to the west of the southern portion of the Buckeye Mine Site have specific conductance ranging from 290 to 380 microSiemens/cm and a spring located to the north of the site has a measured conductivity of 610 microSiemens/cm. Based on these specific conductivity measurements, the waters would qualify as Class I groundwater.

ARM 17.30.1005(2) and (3) (Applicable) provides that it is not necessary to treat discharges to a purer condition than the natural condition of the receiving water, within the meaning of 75-5-306, MCA. Further, groundwater standards may be exceeded within a mixing zone established pursuant to ARM 27.30.501 through 17.30.518.

ARM 17.30.1011 (Applicable) prohibits degradation and states any ground water whose existing quality is higher than the established groundwater quality standards for its classification must be maintained at that high quality in accordance with 75-5-303, MCA and ARM Title 17, chapter 30, subchapter 7.

### 3.1.3 Public Water Supplies Act

EPA has granted the State of Montana primacy in enforcement of the Safe Drinking Water Act. The state regulations under the state Public Water Supply Act, §§ 75-6-101 et seq., MCA, substantially parallel the federal law and are relevant and appropriate.

Public Water Supply Regulations (Relevant and Appropriate)

Note that ARM 17.38.203-207 specifies MCLs for inorganic, organic, turbidity, radiological, and microbiological parameters.

ARM 17.38.205 (Relevant and Appropriate) establishes the following maximum turbidity contaminant level for public water supply systems which use surface water in whole or in part:

1. One turbidity unit ("TU"), as determined by a monthly average, except that a level not exceeding 5 TU may be allowed if the supplier of water can demonstrate to the department that the higher turbidity does not:

(a) interfere with disinfection;

(b) prevent maintenance of an effective disinfectant agent throughout the distribution system; or

(c) interfere with microbiological determination.

2. 5 TU based on an average for two consecutive days.

Although no groundwater is being used at the site for drinking water, at least eighteen domestic water wells (Montana Bureau of Mines and Geology GWIC, 2004) are located in Section 19, Township 4 South and Range 4 West within one mile of the Buckeye Mine Site, therefore, this ARAR is relevant and appropriate.

### 3.1.4 Clean Air Act (Relevant and Appropriate and Applicable)

Air quality regulations pursuant to the Act, §§ 75-2-101 et seq., MCA, are discussed below.

ARM 17.8.222 (Applicable) specifies that no person shall cause or contribute to concentrations of lead in the ambient air which exceed the following: 90-day average -- 1.5 micrograms per cubic meter of air, 90-day average, not to be exceeded.

ARM 17.8.220 (Applicable) specifies that no person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter, 30-day average, not to be exceeded.

ARM 17.8.223 (Applicable) specifies that no person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standard:

1. 24-hour average: 150 micrograms per cubic meter of air, 24-hour average, with not more that one expected exceedance per calendar year.

2. Annual average: 50 micrograms per cubic meter of air, expected annual average, not to be exceeded.

ARM 17.8.304 (2) (Applicable) states that "no person may cause or authorize emissions to be discharged in the outdoor atmosphere from any source installed after November 23, 1968, that exhibit an opacity of 20% or greater averaged over six consecutive minutes."

ARM 17.8.308 (Applicable) states that no person shall cause or authorize the production, handling, transportation, or storage of any material unless reasonable precautions are taken to control emissions of airborne particulate matter.

ARM 17.8.341 (Applicable) adopts the standards of 40 CFR Part 61 setting forth emission standards for hazardous air pollutants.

ARM 17.24.761 (Applicable) requires a fugitive dust control program be implemented in reclamation operations and lists specific but non-exclusive measures as necessary components of such a program.

### 3.1.5 Occupational Health Act

Occupational health regulations pursuant to the Occupational Health Act (see § 50-70-113, MCA) are discussed below.

Occupational Health Regulations (Applicable)

The occupational safety and health laws are applicable protections for employees working at CERCLA sites. See NCP, 40 CFR § 300.150. The occupational health laws identified below prescribe certain limits of exposure considered necessary to protect the health of those with sustained exposure to specified substances. The nature of this removal action may subject persons other than employees to exposures sustained throughout the work period. These limits must be considered relevant and appropriate for those living or present in the areas affected by the removal action.

ARM 17.74.102 (Applicable) establishes maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker (or other person in or near the work site) shall be exposed to air contaminant levels in excess of the threshold limit values listed in each of the tables below. Compliance with the rule is determined by calculating the person's exposure to air contaminants as individual substances or as the exposure to a mixture of substances in accordance with formulas established by this rule. A person's exposure to any contaminant in the following table shall at no time exceed the threshold limit value listed:

| Air Contaminant | Concentration ($mg/m^3$) |
|---|---|
| Arsenic and compounds (as As) | 0.01 |
| Cadmium | 0.005 |
| Chromium | 0.5 |
| Cobalt | 0.1 |
| Copper dust and mist | 1.0 |
| Cyanide | 5.0 |
| Lead | 0.05 |
| Manganese | 5.0 |
| Mercury | 0.1 |
| Molybdenum | |
| Soluble compounds | 5.0 |
| Insoluble compounds | 15.0 |
| Silver, Metal and soluble compounds | 0.01 |
| Zinc | 5.0 |

ARM 17.74.101 (Applicable) establishes occupational noise levels and provides that no worker shall be exposed to noise levels in excess of specified levels.

## 3.2 MONTANA LOCATION-SPECIFIC ARARS

### 3.2.1 Floodplain and Floodway Management Act

Section 76-5-401, MCA, (Applicable) specifies the types of uses permissible in a designated 100-year floodway or floodplain and generally prohibits permanent structures, fill or permanent storage of materials or equipment.

Section 76-5-402, MCA, (Applicable) specifies uses allowed in the floodplain, excluding the floodway, and allows structures meeting certain minimum standards.

Section 76-5-403, MCA, (Applicable) lists certain uses which are prohibited in a designated floodway, including:

- any building for living purposes or place of assembly or permanent use by human beings;
- any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; or
- the construction or permanent storage of an object subject to flotation or movement during flood level periods.

Floodplain Management Regulations

ARM 36.15.216 (Applicable - substantive provisions only) specifies factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway. While permit requirements are not directly applicable to activities conducted entirely on site, the criteria used to determine whether to approve establishment or alteration of an artificial obstruction or nonconforming use should be applied by the decision-makers in evaluating proposed remedial alternatives which involve artificial obstructions or nonconforming uses in the floodway or floodplain. Thus the following criteria are relevant and appropriate considerations in evaluating any such obstructions or uses:

- the danger to life and property from backwater or diverted flow caused by the obstruction;
- the danger that the obstruction will be swept downstream to the injury of others;
- the availability of alternative locations;
- the construction or alteration of the obstruction in such a manner as to lessen the danger;
- the permanence of the obstruction; and
- the anticipated development in the foreseeable future of the area which may be affected by the obstruction.

ARM 36.15.601 (Applicable - substantive provisions only) specifies open space uses which shall be allowed without a permit anywhere in the designated floodway provided that they are not prohibited by any other ordinance or statute and provided that they do not require structures other than portable structures, fill or permanent storage of materials or equipment.

ARM 36.15.602 (Applicable - substantive provisions only) specifies conditions for allowing certain artificial obstructions in a designated floodway, including conditions for excavation of material from pits or pools within the floodway.

ARM 36.15.603 (Applicable - substantive provisions only) provides that proposed diversions or changes in place of diversion must be evaluated by the Montana Department of Natural Resources and Conservation (MDNRC) to determine whether they may significantly affect flood flows and, therefore, require a permit.  While permit requirements are not applicable for remedial actions conducted entirely on site, the following criteria used to determine when a permit shall not be granted are relevant and appropriate:

- The proposed diversion will increase the upstream elevation of the 100-year flood a significant amount (one-half foot or as otherwise determined by the permit issuing authority).

- The proposed diversion is not designed and constructed to minimize potential erosion from a flood of 100-year frequency.

- Any permanent diversion structure crossing the full width of the stream channel is not designed and constructed to safely withstand up to a flood of 100-year frequency.

ARM 36.15.604 (Applicable - substantive provisions only) precludes new construction or alteration of an artificial obstruction that will significantly increase the upstream elevation of the flood of 100-year frequency (0.5 feet or as otherwise determined by the permit issuing authority) or significantly increase flood velocities.

ARM 36.16.605(1) and (2) (Applicable - substantive provisions only) enumerate artificial obstructions and non-conforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway...".  Solid and hazardous waste disposal and storage of toxic, flammable, hazardous, or explosive materials are also prohibited.

ARM 36.15.606 (Applicable - substantive provisions only) enumerates flood control works that are allowed within designated floodways pursuant to permit.  Although the permit requirements are not applicable for activities conducted entirely on site, the following conditions are relevant and appropriate:

- Flood control levies and flood walls are allowed if they are designed and constructed to safely convey a flood of 100-year frequency, and their cumulative effect combined with allowable flood fringe encroachments does not increase the unobstructed elevation of a flood of 100-year frequency more than one-half foot at any point.

- Riprap, if not hand placed, is allowed if it is designed to withstand a flood of 100-year frequency; does not increase the elevation of the 100-year frequency flood; and will not increase erosion upstream, downstream, or across stream from the riprap site.

- Channelization projects are allowed if they do not significantly increase the magnitude, velocity, or elevation of the flood of 100-year frequency downstream from such projects.

- Dams are allowed if they are designed and constructed in accordance with approved safety standards and they will not increase flood hazards downstream either through operational procedures or improper hydrologic design.

ARM 36.15.701 (Applicable) requires that, within the flood fringe area, public or private structures and facilities for liquid or solid waste treatment and disposal must be flood-proofed to ensure that no pollutants enter flood waters.

ARM 36.15.703 (Applicable) is applicable in flood fringe areas (i.e., areas in the floodplain but outside of the designated floodway) of the site and prohibits, with limited exceptions, solid and hazardous waste disposal and storage of toxic, flammable, hazardous, or explosive materials.

ARM 36.15.801 (Applicable) states that wildlife management and natural areas are permitted and encouraged uses within a floodplain.

The Buckeye Mine Site is not located in a designated 100-year floodplain.

### 3.2.2 Natural Streambed and Land Preservation Act

<u>Natural Streambed and Land Preservation Standards</u>

Reclamation activities proposed for the Buckeye Mine Site will not alter or affect a perennial stream. Tailings TP-5 and waste rock WR-5 piles are adjacent to Mill Creek, but excavation of these wastes should not directly impact the Mill Creek perennial stream. Section 87-5-501, MCA, (Applicable) declares that the fish and wildlife resources of the State of Montana, particularly the fishing waters, are to be protected and preserved to the end that they be available for all time, without change, in their natural existing state except as may be necessary and appropriate after due consideration of all factors involved.

Sections 87-5-502 and 504, MCA, (Applicable - substantive provisions only) provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or vary the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat. This requirement is relevant and appropriate for entities carrying out remedial actions approved by the state.

ARM 36.2.410 (Applicable) defines project information which applicant must provide to the conservation district and provides that stream must be designed and constructed to minimize adverse impacts to stream, future disturbances to the stream and erosion; temporary structures used during construction must handle reasonably anticipated high flows; channel alteration must be designed to retain original stream length or otherwise provide for hydrologic stability; streambank vegetation must be protected except where removal is necessary and riprap, rock, or other material must be sized adequately to protect streambank erosion.

### 3.2.3 Antiquities Act

Section 22-3-424, MCA, (Relevant and Appropriate) requires that the identification and protection of heritage properties and paleontological remains on lands owned by the state are given appropriate consideration in state agency decision-making. With the exception of the lands containing waste rock piles WR1, WR2 and WR3, property in the vicinity of the Buckeye Mine Site is primarily private lands consisting of patented mining claims. The U.S. Bureau of Land Management administers that portion of the Buckeye Mine Site that is not private ownership. The Antiquities Act is applicable only to state lands, but is relevant and appropriate in decision-making affecting other properties. Heritage property is defined in § 22-3-421, MCA, as any district, site, building, structure, or object located upon or beneath the earth or under water that is significant in American history, architecture, archaeology, or culture.

Section 22-3-433, MCA, (Relevant and Appropriate) requires that evaluation of environmental impacts include consultation with the historic preservation officer concerning the identification and location of heritage properties and paleontological remains on lands that may be adversely impacted by the proposed action. The responsible party, in consultation with the historic preservation officer and the preservation review board, shall include a plan for the avoidance or mitigation of damage to heritage properties and paleontological remains to the greatest extent practicable. (Applicable only to state lands, but is relevant and appropriate in decision-making affecting other properties).

Section 22-3-435, MCA, (Relevant and Appropriate) requires any person conducting activities, including survey, excavation or construction, who discovers any heritage property or paleontological remains or who finds that an operation may damage heritage properties or paleontological remains shall promptly report to the historic preservation officer the discovery of such findings and shall take all reasonable steps to ensure preservation of the heritage property or paleontological remains. (Applicable only to state lands, but is relevant and appropriate in decision-making affecting other properties).

<u>Cultural Resources Regulations</u>

ARM 12.8.501 through 12.8.508 (Relevant and Appropriate) prescribe specific procedures to be followed to ensure adequate consideration of cultural values in agency decision-making.

## 3.3 MONTANA ACTION-SPECIFIC ARARS

### 3.3.1 Water Quality Act (Applicable)

Section 75-5-605, MCA, makes it unlawful to cause pollution of any state waters or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any State waters.

<u>Surface Water Quality Standards (Applicable)</u>

ARM 17.30.610 (1) (Applicable) provides that specified waters in the Missouri River drainage, including the Mill Creek drainage, are classified B-1 for water use.

The standards for B-1 classification waters are contained in ARM 17.30.623 (Applicable) of the Montana Water Quality regulations. These standards place limits on fecal coliform content, dissolved oxygen concentration, pH balance, turbidity, water temperature, sediments, solids, oils and color. Concentrations of toxic or deleterious substances which would remain in the water after conventional treatment cannot exceed applicable standards set forth in department Circular WQB-7.

Additional restrictions on any discharge to surface waters are included in:

ARM 17.30.635 (Applicable), which requires that industrial waste must receive, as a minimum, treatment equivalent to the best practicable control technology currently available (BPCTCA) as defined in 40 CFR Subchapter N and subsequent amendments. Industrial waste is defined in Section 75-5-103, MCA as any waste substance from the process of business or industry or from the development of any natural resource, together with any sewage that may be present. ARM 17.30.635 also requires that in designing a disposal system, stream flow dilution requirements must be based on the minimum consecutive 7-day average flow which may be expected to occur on the average of once in 10 years.

ARM 17.30.637 (Applicable), which prohibits discharges containing substances that will:

(a) settle to form objectionable sludge deposits or emulsions beneath the water's surface or upon adjoining shorelines;

(b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;

(c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;

(d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; or

(e) create conditions which produce undesirable aquatic life.

ARM 17.30.637(4) and (10) also provide that leaching pads, tailing ponds, water, waste, or product holding facilities must be located, constructed, operated, and maintained to prevent any discharge, seepage, drainage, infiltration, or flow which may result in pollution of state waters. A monitoring system may be required to ensure such compliance. No pollutants may be discharged and no activities may be conducted which, either alone or in combination with other wastes or activities, result in the total dissolved gas pressure relative to the water surface exceeding 110 percent of saturation. The rule also sets out other general prohibitions one should review for any site specific conditions.

ARM 17.30.505-508 provides that discharges to surface waters and groundwaters may be granted a mixing zone on a case by case basis by the DEQ in accordance with its written implementation policy. In granting a mixing zone, the department shall ensure (1) surface water and ground water quality human health and aquatic life standards must not be exceeded beyond the mixing zone; (2) discharges to wetlands (other than constructed wetlands) will not be granted a mixing zone for parameters for which the state has adopted numeric acute or chronic standards for aquatic life or for human health in the surface water quality standards unless (a) the standards will not be exceeded beyond the boundaries of the mixing zone, (b) existing beneficial uses will not be threatened or harmed; and (c) the conditions in 75-5-303(3), MCA are met; (3) for discharges to surface water that first pass through the ground, such discharges from infiltration systems or land application areas, the surface water mixing zone begins at the most upstream point of discharge into the receiving surface water. If the discharge continues to occur downstream beyond a distance equal to 10 times the stream width measured at the upstream discharge point at low flow, a standard mixing zone will not be granted and (4) no mixing zone for groundwater will be allowed if the zone of influence of an existing drinking water supply well will intercept the mixing zone.

ARM 17.30.1203 (Applicable), which adopts and incorporates the provisions of 40 CFR Part 125 for criteria and standards for the imposition of technology-based treatment requirements in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology (BAT) economically achievable; for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BAT/BCT technology-based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7.

The Water Quality Act and regulations also include nondegradation provisions (17.30.701 <u>et seq</u>.) which require that waters which are of higher quality than the applicable classification be maintained at that high quality, and discharges which would degrade that water are prohibited. Montana's standard for nondegradation of water quality is applicable for all constituents for which pertinent portions of the Mill Creek are of higher quality than the B-1 classification. If any remedial action constitutes a new source of pollution or an increased source of pollution, the nondegradation standard requires the degree of waste treatment necessary to maintain the existing water quality for constituents that are of higher quality than the applicable classification. Categories of activities that cause non-significant changes in water quality are described in ARM 17.30.716. Informational requirements for non-degradation significance/authorization review, department procedures, and criteria for determining non-significant changes in water quality are presented in ARM 17.30.706-715.

The MPDES permit requirements are technically not applicable to remedial actions at CERCLA sites because ARM 16.20.1305(3) exempts "Any discharge in compliance with the instructions of an on-scene coordinator pursuant to 40 CFR Part 300 <u>e</u>t <u>seq</u>. (the NCP)." This exemption is even broader than the 121(e) permit exemption, because it would apply even to an off-site discharge, if such discharge were "in compliance with the instructions of the OSC." The MPDES requirements could still be relevant and appropriate to discharges of pollutants as part of a remedial action. However, it would probably be more appropriate to identify the federal requirements as the relevant and appropriate requirements because of the express state exemption, which arguably represents a determination that the state MPDES requirements are not relevant or appropriate. Note that this analysis does not apply to a site being addressed only under CECRA and not CERCLA, because the exemption applies only to the instructions of an OSC under the NCP.

The MPDES standards (the substantive requirements to be enforced through the permitting process) are set out in 17.30.1203, <u>et seq</u>. These standards are all simply incorporation of the federal regulations, some of which are included as ARARs, for example:

> ARM 17.30.1206 (Relevant and Appropriate) adopts and incorporates language for toxic pollutant effluent standards found in 40 CFR Part 129.
>
> ARM 17.30.1207 (Relevant and Appropriate) adopts and incorporates language for effluent limitations and standards of performance found in 40 CFR Subchapter N (Parts 401-471, except Part 403).

ARM 17.30.1208 (Relevant and Appropriate) adopts and incorporates language for hazardous substances found in 40 CFR Part 116.

ARM 17.30.1209 (Relevant and Appropriate) adopts and incorporates language for minimum treatment requirements for secondary treatment or the equivalent for publicly owned treatment works (POTW's) and for certain industrial categories found in 40 CFR Part 133.

### 3.3.2 Montana Groundwater Act

<u>Montana Groundwater Pollution Control System (Applicable)</u>

ARM 17.30.1006 (Applicable) classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and establishes groundwater classification standards. Groundwater is classified based on the natural specific conductance of the water (ARM 17.30.1005). Class I is the highest quality class; class IV the lowest. ARM 17.30.1006 provides that Class I groundwaters have a specific conductance (SC) of less than 1,000 microSiemens/cm at 25° C. The SC of groundwater at the Buckeye Mine Site is unknown for there are no ground water wells or flowing adits available for monitoring specific conductance within the site boundary. However, water tested in two private wells located immediately to the west of the southern portion of the Buckeye Mine Site have specific conductance ranging from 290 to 380 microSiemens/cm and a spring located to the north of the site has a measured conductivity of 610 microSiemens/cm. Based on these specific conductivity measurements, the waters would qualify as Class I groundwater.

ARM 17.30.1011 (Applicable) provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA and ARM Title 17, Chapter 30, Subchapter 7.

### 3.3.3 Clean Air Act

<u>Air Quality Regulations (Applicable)</u>

Dust suppression and similar actions may be necessary to control the release of substances into the air as a result of earth moving and transportation of mine/mill wastes both off- and on-site. The ambient air standards for specific contaminants and for particulates are set forth in the federal contaminant-specific section above. The levels of certain substances that may not be exceeded are identified in the Air Quality section of the contaminant-specific State ARARs. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 <u>et</u> <u>seq</u>., MCA, are discussed below.

ARM 17.8.221 (Applicable) specifies that no person shall cause or contribute to concentrations of lead in the ambient air which exceed the following: 90-day average-1.5 micrograms per cubic meter of air, 90-day average, not to be exceeded.

ARM 17.8.604 (Applicable) lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the premises where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry or demolition project) may be open burned only in accordance with the substantive requirements of 17.8.611 or 612. Open burning means combustion of any material directly in the open air without a receptacle, or in a receptacle other than a furnace, multiple chambered incinerator or wood waste burner, ARM 17.8.601(7).

ARM 17.8.308 (Applicable) states that no person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions are taken to control emissions of airborne particulate matter.

ARM 17.8.304 (Applicable) states that "no person may cause or authorize emissions to be discharged in the outdoor atmosphere...that exhibit an opacity of twenty percent (20 percent) or greater averaged over six consecutive minutes."

ARM 17.8.324 (Applicable) prohibits storage tanks for any crude oil, gasoline, or certain petroleum distillates of more than 65,000 gallons capacity unless it conforms to the requirements of this section.

### 3.3.4 Solid Waste Management Act

Several regulations promulgated under the Solid Waste Management Act, §§ 75-10-201 et seq., MCA, and the Hazardous Waste Management Act, §§ 75-10-401 et seq., MCA, are discussed in the federal section of ARARs, because they implement those federal programs in the State. The Solid Waste Management Act was significantly revised in the 1995 Montana Legislature.

Solid Waste Management Regulations

ARM 17.50.504 (Applicable) restricts the types of wastes that disposal sites may handle.

ARM 17.50.505 (Applicable) sets forth standards that all solid waste disposal sites must meet.

ARM 17.50.508 (Relevant and Appropriate) is the provision that establishes the solid waste management system license application. Although a license would not be required for remedial activity conducted entirely on site, the information required by this section is relevant and appropriate.

ARM 17.50.509 (Applicable) sets forth that every proposed solid waste management system must be evaluated, taking into consideration the physical characteristics of the disposal site, the types and amount of waste, the operation and maintenance plan for the system, and the plan for reclamation and the land's ultimate use.

ARM 17.50.510 and 17.50.511 (Applicable) set forth the general and specific operation and maintenance requirements for solid waste management systems.

ARM 17.50.523 (Applicable) specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle.

### 3.3.5 Hazardous Waste Management Act (Relevant and Appropriate)

ARMs 17.54.111, 17.54.112 and 17.54.119 (Relevant and Appropriate) establish permit conditions, including monitoring, record keeping requirements, operation and maintenance requirements, sampling and monitoring requirements, and the option for DEQ to establish additional permit conditions on a case-by-case basis.

ARMs 17.54.130 and 17.54.131 (Relevant and Appropriate) state the required contents of a Hazardous Waste Management (HWM) permit application. The information and substantive requirements of these provisions are relevant and appropriate.

ARM 17.54.351 (Relevant and Appropriate) gives hazardous waste sampling protocols, testing methods, and analytical procedures.

ARM 17.54.401 through 17.54.418 and 17.54.501 through 17.54.527 (Relevant and Appropriate) set forth the standards and requirements for generators and transporters of hazardous waste.

ARMs 17.54.701 through 17.54.705 (Relevant and Appropriate) establish hazardous waste management facility standards and requirements.

ARMs 17.54.801 through 17.54.833 (Relevant and Appropriate) set the financial assurance requirements for closure of hazardous waste management facilities.

### 3.3.6 Strip and Underground Mine Reclamation Act

The Buckeye Mine Site is an abandoned hardrock mine/mill site. Regulations promulgated under Montana's Strip and Underground Mine Reclamation Act §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the impacts of mine reclamation activities and earth moving projects and may be relevant and appropriate for addressing these impacts in DEQ-MWCB reclamation projects.

The hydrology regulations promulgated under the Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth moving projects and may be relevant and appropriate for addressing these impacts in Mine Waste Cleanup Bureau (MWCB) reclamation projects.

ARM 17.24.631 (Relevant and Appropriate) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, depth to groundwater, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainages to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting run-off, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 17.24.633 (Relevant and Appropriate) states that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 17.24.634 (Relevant and Appropriate) provides that drainage design shall emphasize channel and floodplain pre-mining configuration that blends with the undisturbed drainage above and below and provides specific requirements for designing the reclaimed drainage to:

- meander naturally;
- remain in dynamic equilibrium with the system;
- improve unstable pre-mining conditions;
- provide for floods; and
- establish a pre-mining diversity of aquatic habitats and riparian vegetation.

ARM 17.24.635 through 17.24.637 (Relevant and Appropriate) set forth requirements for temporary and permanent diversions.

ARM 17.24.640 (Relevant and Appropriate) provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

Section 82-4-231, MCA, (Relevant and Appropriate) sets forth that as rapidly, completely and effectively as the most modern technology and the most advanced state of the art will allow, each operator shall reclaim and revegetate the land affected by his operation. The operator must grade, backfill, topsoil, reduce highwalls, stabilize subsidence, and control water. In so doing all measures must be taken to eliminate damage from soil erosion, subsidence, land slides, water pollution, and hazards dangerous to life and property.

In addition, this section directs the operator to employ various specific reclamation measures such as:

- burying under adequate fill all toxic materials, shale, minerals, or any other material determined by DEQ to be acid producing, toxic, undesirable, or creating a hazard;
- impounding, draining, or treating all run-off waters so as to reduce soil erosion, damage to grazing and agricultural lands, and pollution of surface and subsurface waters;
- stockpiling and protecting all mining and processing wastes from erosion until these wastes can be disposed of according to the provisions of this part;
- minimizing disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values;
- minimizing disturbances to surface and groundwater systems by avoiding acid or other toxic mine drainage by such measures as, but not limited to, preventing or removing water from contact with toxic-producing deposits and treating drainage to reduce toxic content which adversely affects downstream water upon being released to water courses; and

- stabilizing and protecting all surface areas, including spoil piles to effectively control air pollution.

Section 82-4-233, MCA, (Relevant and Appropriate) provides that after grading, the operator must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration. The vegetative cover must be capable of:

- feeding and withstanding grazing pressure from a quantity and mixture of wildlife and livestock;

- regenerating under the natural conditions prevalent at the site; and

- preventing soil erosion to the extent achieved before the operation.

ARM 17.24.501 (Relevant and Appropriate) gives general backfilling and final grading requirements.

ARM 17.24.519 (Relevant and Appropriate) provides that an operator may be required to monitor settling of regraded areas.

ARM 17.24.638 (Relevant and Appropriate) specifies sediment control measures to be implemented during operations.

ARM 17.24.641 (Relevant and Appropriate) sets forth methods for prevention of drainage from acid- and toxic-forming spoils into ground and surface waters.

ARM 17.24.642 (Relevant and Appropriate) prohibits permanent impoundments with certain exceptions and sets standards for temporary and permanent impoundments.

ARM 17.24.643 through 17.24.646 (Relevant and Appropriate) provide for groundwater protection, groundwater recharge protection, and surface and groundwater monitoring.

ARM 17.24.649 (Relevant and Appropriate) prohibits the discharge, diversion, or infiltration of surface and groundwater into existing underground mine workings.

ARM 17.24.701 and 17.24.702 (Relevant and Appropriate) require that during the removal, redistributing, and stockpiling of soil (for reclamation):

- The operator shall limit the area from which soil is removed at any one time to minimize wind and water erosion, and the operator shall take other measures, as necessary, to control erosion.

- Regraded areas must be deep-tilled, subsoiled, or otherwise treated to eliminate any possible slippage potential, to relieve compaction, and to promote root penetration and permeability of the underlying layer. This preparation must be done on the contour whenever possible and to a minimum depth of 12 inches.

- The operator shall, during and after redistribution, prevent, to the extent possible, spoil and soil compaction; protect against soil erosion, contamination, and degradation; and minimize the deterioration of biological properties of the soil.

- Redistribution must be done in a manner that achieves approximate uniform thickness consistent with soil resource availability and appropriate for the post-mining vegetation, land uses, contours, and surface water drainage systems.

- Redistributed soil must be reconditioned by subsoiling or other appropriate methods.

ARM 17.24.703 (Relevant and Appropriate) requires that when using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material: 1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use; and 2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.

ARM 17.2.711 (Relevant and Appropriate) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural (or pre-existing) vegetation during each season of the year.

ARM 17.24.713 (Relevant and Appropriate) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation but may not be more than 90 days after soil has been replaced.

ARM 17.24.714 (Relevant and Appropriate) requires use of mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 17.24.716 (Relevant and Appropriate) establishes the required method of revegetation and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 17.24.717 (Relevant and Appropriate) give requirements for tree planting if necessary to comply with MCA 82-4-233.

ARM 17.24.718 (Relevant and Appropriate) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures if necessary to establish a diverse and permanent vegetative cover.

ARM 17.24.719 (Relevant and Appropriate) prohibits livestock grazing on reclaimed land until the seedlings are established and can sustain managed grazing.

ARM 17.24.721 (Relevant and Appropriate) specifies that rills or gullies deeper than nine inches must be stabilized. In some instances, more shallow rills and gullies must be stabilized.

ARM 17.24.723 (Relevant and Appropriate) provides that the operator shall conduct approved periodic monitoring of vegetation, soils and wildlife.

ARM 17.24.724 (Relevant and Appropriate) provides that revegetation success must be measured by approved, unmined, reference areas. There shall be at least one reference area for each plant community type. Required management for these reference areas is set forth.

ARM 17.24.726 (Relevant and Appropriate) sets forth the required methods for measuring productivity of revegetated areas.

ARM 17.24.728 (Relevant and Appropriate) sets forth requirements for the composition of vegetation on reclaimed areas.

ARM 17.24.730 and 17.24.731 (Relevant and Appropriate) provide that the revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area. If toxicity to plants or animals is suspected, comparative chemical analyses may be required.

ARM 17.24.733 (Relevant and Appropriate) provides additional requirements and measurement standards for trees, shrubs, half-shrubs, and other woody plants.

ARM 17.24.751 (Relevant and Appropriate) mandates specific measures that must be undertaken or actions that must be refrained from to enhance or prevent harm to fish, wildlife, and related environmental values.

ARM 17.24.761 (Relevant and Appropriate) specifies measures that must be implemented to control fugitive dust emissions during certain mining and reclamation activities. Such measures would be relevant and appropriate requirements to control fugitive dust emissions during excavation, earth moving, and transportation activities conducted as part of the remedy at the site.

### 3.3.7 Natural Streambed and Land Preservation Act (Applicable)

Section 75-7-102, MCA, and ARM 36.2.410 (Applicable), which place limitations on and specify criteria to be considered in approving projects affecting streambeds, would be applicable (substantive provisions only) if alternative developed alters or affects a streambed.

## 3.4 OTHER MONTANA LAWS

The following "other laws" are included here to provide a reminder of other legally applicable requirements for actions being conducted at the site. They do not purport to be an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning. They are not included as ARARs because they are not “environment or facility siting laws” and they are not subject to ARAR waiver provisions.

The administrative/substantive distinction used in identifying ARARs applies only to ARARs and not to other applicable laws. Thus even the administrative requirements (e.g., notice requirements) of these other laws must be complied with in this action. Similarly, fees that are based on something other than issuance of a permit are applicable.

### 3.4.1 Montana Safety Act (Applicable)

Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

### 3.4.2 Employee and Community Hazardous Chemical Information Act (Applicable)

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain (at the work place) a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemical at the work place and trained in the proper handling of the chemicals.

### 3.4.3 Water Rights (Relevant and Appropriate)

Section 85-2-101, MCA, declares that all waters within the State are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-301, MCA, of Montana law, provides that a person may only appropriate water for a beneficial use.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefore except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation (DNRC). While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system. A 1991 amendment imposes a fee of $1.00 per acre foot for appropriations of groundwater, effective until July 1, 1993.

Section 85-2-306, MCA, specifies the conditions on which groundwater may be appropriated, and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.

Section 85-2-311, MCA, specifies the criteria which must be met in order to appropriate water and includes requirements that:

1. there are unappropriated waters in the source of supply;

2. the proposed use of water is a beneficial use; and

3. the proposed use will not interfere unreasonably with other planned uses or developments.

Section 85-2-402, MCA, specifies that an appropriator may not change an appropriated right except as provided in this section with the approval of the DNRC.

Section 85-2-412, MCA, provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water, over and above what is actually and necessarily used, such surplus must be returned to the stream.

### 3.4.4 Groundwater Act

Section 85-2-516, MCA, states that within 60 days after any well is completed a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder.

### 3.4.5 Water Well Contractors, §§ 37-43-101 et seq., MCA

ARM 36.21.402 provides that any person who drills or otherwise constructs water wells must have a State license.

ARM 36.21.403, 36.21.405, 36.21.406 and 36.21.411 provide requirements for obtaining a license, contents of an application and bonding requirements.

### 3.4.6 Well Construction Standards

ARM 36.21.635 through 36.21.680 set forth water well construction criteria, public water supply wells criteria, well location requirements, and reporting requirements.

ARM 36.21.701 and 36.21.703 specify that monitoring well constructors must be licensed and must verify their experience.

### 3.4.7 Occupational Health Act of Montana, §§ 50-70-101 et seq., MCA

ARM 17.74.101 provides that no worker shall be exposed to noise levels in excess of the following values (expressed in decibels measure on the A-weighting network (dbA)):

Continuous or Intermittent Noise Exposures

| Duration per Day (in hours) | Noise Level (dbA) |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1-½ | 102 |
| 1 | 105 |
| ¾ | 107 |
| ½ | 110 |
| ¼ | 115 |

These values apply to the total time of exposure per working day regardless of whether or not this is one continuous exposure or a number of short-term exposures. If a worker is exposed to noise levels in excess of these values, feasible administrative or engineering controls must be used by the employer to reduce nose levels. If these controls are inadequate, the employer must provide personal hearing protective equipment to achieve the foregoing maximum permissible noise exposure levels. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM § 17.74.102 addresses occupational air contaminants. This rule establishes maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.